TRANSACTIONS

OF THE

ILLUMINATING ENGINEERING SOCIETY

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TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

VOL. XVII JANUARY, 1922 NO. 1

A Message
From Our President

WHEN THIS SOCIETY was organized sixteen years ago it was felt by some that there was hardly a need for such specialization. There was a splitting off from the parent electrical and other societies, but the charter members were men of broad vision, together with the other virtues of training and ability to work, and the child was born and has since amply justified its existence. The first president, L. B. Marks, who still watches and advises the progeny as carefully as in the early days, was frank and honest in the statement in which he outlined the scope of the society. There must have been a desire on the part of some of the charter members to make it a society of and for illuminating engineers alone, thereby following the example of the older societies; but Mr. Marks, in his wisdom, declared; "The term 'engineering' as used in the name of this society, unless used in its broad sense, is to a certain extent a misnomer, as the society will deal with some phases of illumination that may not properly be said to come within the distinct field of engineering, such, for instance, as the physiological side of the question. The society will be interested in every phase of the subject of illumination, whether from an engineering point of view or otherwise, and will throw its doors quite as wide open to the layman as to the professional." This pronouncement has been fully lived up to by the society to this day, as witness the honoring of an ophthalmologist with its highest office. Let us hope that in the future an architect will also be so honored, thus spreading broadly the propaganda of artistic lighting in its fullest and safest efficiency.

When the architect really becomes one of us and the close association breeds a more complete mutual confidence we shall make strides as never before.

It is not long since the fixture manufacturer was considered a being who measured artistic illumination in terms of brass, but now the fixture man, the manufacturer of luminaires, to use the new term, works with the illuminating engineer in the development of the most efficient and at the same time artistic units. That all the fixture people have not seen the light must be admitted, but there is a gradually increasing tendency to work with the illuminating engineer.

When one looks about him and realizes the progress that this society has made in the many phases of its activity and also sadly contemplates the fields that as yet have hardly been touched, such as school lighting and the lighting of the older factories, it hardly seems possible that some men without vision said there was no need of an illuminating engineering society. However, history repeats itself. In looking over the names of the pillars of the Optical Society of America one realizes whence it sprang, and yet some said there was no need of an optical society. In five short years it has made strides that fully justify its being, and most of its work is special and of interest principally to students of optics.

As before stated, much remains to be accomplished in our special field of good lighting, and to this end our propaganda must be spread broadcast, the propaganda of the conservation of vision, of efficient lighting combined with art in living color.

Our society is healthy but too contented, and contentment is not always a good symptom, sometimes it spells stagnation. Reference is made to the fact that we are satisfied to have strong sections and chapters in a certain number of cities while many

other almost equally important centers are allowed to make out as best they can without the stimulus of local organization.

A careful study of this subject is being made at the present time by two special committees—the national committee on membership, piloted by G. B. Regar of Philadelphia, and the committee on new sections and chapters, whose chairman is D. McFarlan Moore of Harrison, N. J. To know these men is to expect results, but they need the assistance of every member of the society. This does not mean the other members of the society, gentle reader, it means you. Let us all help with a feeling of altruism in order that our propaganda may reach to every corner of the country. Where there are eyes to see let them see.

George S. Crampton

An Announcement

WITH THIS ISSUE the Transactions appears in a revised form with the hope of making it more newsy and interesting to the members of our society. Volume XVII begins with the January number and will be published monthly with the exception of June, July and August. During the summer months one number will be published about the middle of July.

In rearranging the make-up, some new departments have been added. The editorial section features "A Message from our President" and in each subsequent issue messages will be run from those members contributing constructive suggestions for further activities of the Society.

The section entitled "Reflections" is introduced with the thought of acquainting the membership with important items of general interest in illumination. "Society Affairs," which will be found after the section devoted to "Papers," has been expanded.

The Committee takes this opportunity to urge co-operation and help from the members in making the Transactions newsy. Items of interest, personals, and any suggestions for betterment of the Transactions will be appreciated, and should be sent to the editorial office.

Committee on Editing and Publication.

Co-operation of Architects and Engineers Needed for Proper Illumination

MANY building interiors and exteriors which might have been architecturally beautiful have been spoiled either because an architect who was not an illuminating engineer tried to design the lighting or because the requirements of the illuminating engineer were not taken into consideration in laying out the architectural scheme. Such unfortunate situations could be prevented if architects and illuminating engineers would come to a mutual understanding that they have a common purpose and that neither one can produce effective results without full co-operation from the beginning. Attempts have been made by the Illuminating Engineering Society through its reciprocal relations committee to bring about such co-operation, but in general these efforts have been futile. Sometimes where individuals have attempted the solution the architect has believed that the engineer was trying to tell him how he should design the structure; at other times the engineer has felt that the architect was specifying things beyond his sphere of knowledge. No doubt both sides have often been at fault in the past, but that should not prevent their putting petty jealousies aside and attacking the problem anew. Both are experts in their respective fields and each should respect the other's knowledge. Co-operation can be expected only where the engineer looks to the architect for advice regarding the application of illumination fundamentals in an artistic way, and the architect must tell the engineer what effects he wishes to accomplish and then, if necessary, must so modify his design that illuminating equipment may be selected and laid out with the least possible hindrance.

It is hoped that any further attempts of the Illuminating Engineering Society to bring about co-operation between architects and engineers will meet with more success. However, the results to be desired will be gained only if engineers prove to architects that the efforts are being made for mutual benefit.—Editorial, *Electrical World*, Jan. 28, 1922.

REFLECTIONS

Illumination at Washington Conference

THE SCHEME of illumination at the opening of the Conference for the Limitation of Armament consisted of four separate features; namely, Avenue of Light, Jeweled Portal, Washington Monument and the Lights of States at the Capitol grounds. These four features virtually tied the entire city together in one general illuminating plan.

Avenue of Light

Gas was used as the principal illuminant for four blocks on Seventeenth Street, which was known as the Avenue of Light. The electric fixtures were removed from thirty-two city lighting standards and replaced by four burner gas lamps of Roman design. The gas supply was obtained by laying pipe mains just underneath the parking surface along the curb line, and feed pipes running to the lamps were laid directly against the standard. In addition to the gas lamps there were twelve banner standards which illuminated the Pan American Union Building, the Continental Hall and the Red Cross Building. The reflected light from these buildings also helped to build up the general illumination on the street. Each standard was equipped with six 1000-watt incandescent lamps in Ivanhoe metal units and 16-inch glass ball globes. These standards were 35 ft. high, each supporting three banners sufficiently large to shield the lamps from the direct line of vision of the pedestrians on the street.

Five hundred-watt flood lighting projectors were placed on the ground underneath the shrubbery in front of the Pan American Union Building and located in such a manner as to train the beam up through the shrubbery and create relief and color effects.

Jeweled Portal

The jeweled portal was erected across Seventeenth Street at B, which was the south end of the Avenue of Light and in close proximity to the Pan American Union Building where the Conference for the Limitation of Armament was held. The portal consisted of two obelisks, 66 ft. high, 16 ft. square at the base and 3 ft. 8 inches square at the top. These obelisks were 86 ft. 6 inches apart on centers. Between these two obelisks at a height of 40 ft. was suspended a curtain of jewels with a center sunburst containing the Coats of Arms and National Flags of the eight principal participating nations. Approximately 36,000 47 mm. Novagem jewels were used on the two obelisks and curtain.

The obelisks were constructed by using a 70 ft. pole sitting 7 ft. in the ground as a core to support the cables carrying the jeweled curtain and necessary guy lines. The obelisk framing was built

up around these poles and sided in with tongue and groove lumber, which in turn was covered with building paper and canvas, then painted with outdoor water-proof paint to resemble travertine stone. Each obelisk carried eight pieces of plaster ornament, four of which were of the nature of a fluted column with flaring cap to house incandescent lamps and steam outlets.

The portal was lighted by thirty 18-inch arc searchlight projectors located at five stations—two stations south of the monument with six projectors each and three stations on the north with five, six and seven projectors each respectively. In addition to the 18-inch projectors five 60-inch open type Army projectors were used at various locations around the portal.

Washington Monument

The Washington monument was lighted by sixteen 18-inch arc searchlight projectors, equally spaced around the base. Beams from these projectors were trained on glass mirrors set at an angle against the monument in such a way as to re-direct the beam the full height of the shaft. In addition there were fourteen 18-inch projectors placed at the top level of the monument, the beams of which were trained on various public buildings throughout the city which virtually tied the entire city together. Seven Army Cadillac power units were used to supply current to all projectors used in connection with the illumination of the monument.

Lights of States

The Lights of States or so-called Aurora Borealis was produced by the use of twenty-four 24-inch G. E. high intensity Navy type arc searchlight projectors. These projectors were located in a single line along the southeast front of the Congressional Library building and trained so as to form a huge fan lying low over the top of the National Capitol, which, when viewed from a distance, appeared to be emanating from the dome of the Capitol building.

The searchlights used throughout the general scheme were supplied with screens of various colors which enabled the creation of various novel color effects throughout the period of illumination.

Model of Home Lighting

ONE OF THE most interesting features of the exhibit of the Committee on Education at the Fixture Show in Milwaukee was a miniature apartment designed to show properly applied artificial lighting. This was loaned by the Edison Lamp Works and was made by Berthold Audsley, who is probably the foremost artist in this line in the world.

Fig. 1. The Jeweled Portal.

Fig. 2—Night Illumination of the Jeweled Portal

The apartment is four feet square built on a scale of one inch equals one foot and consists of dining room, living room, bedroom, hall, bath and kitchen. Each room is lighted in an artistic, comfortable and effective manner. Miniature furniture of period design is provided, wall coverings, drapes and the like are harmonious.

The most minute details are given consideration in order to get the play of light shade and color such as would be found in the actual installation. For example, instead of merely painting the backs of books on a card and inserting these in the book-case, each little book about ¾" high is separate. Special wine glasses, dishes and vases have been blown by experts and hand decorated.

Miniature tungsten lamps are the light sources, and direct, semi-indirect and totally indirect systems are shown in use. Ceiling units, portable lamps, bracket luminares and even concealed lighting at the top of the book-cases, can be demonstrated at will.

Industrial Lighting Exhibit at Boston

THE BOSTON Industrial Lighting Exhibit was opened June 14, 1921, and is installed in the Rogers Building of the Massachusetts Institute of Technology, 491 Boylston St., Boston, in the heart of the hotel and educational section of the city.

The installation consists of the usual lighting systems and apparatus found in an exhibit of this sort, and has been erected in a first-class manner with the purpose in view of being used a number of years.

During the summer months, efforts were made to acquaint the electrical interests of New England with the Exhibit and its purpose. This was done by having contractors' meetings, jobbers' sales conferences, central station committee meetings, engineering society assemblies, and other meetings of an electrical nature held in the room housing the Exhibit.

As the lighting season approached, careful watch was kept on the Associations holding conventions in Boston and a demonstration of the Lighting Exhibit was incorporated in the convention program of such organizations as the National Safety Council, National Association of Cotton Manufacturers, Associated Industries of New England, Commercial Engineers' Association, and many others.

The use of the room has been offered to the local associations that the subject of lighting might be of interest, and a demonstration of the Exhibit given at the close of the meeting. Associations such as the Chamber of Commerce, Society of Architects, State Institution Engineers, College and Secondary Science Teachers, Industrial Hygiene Doctors, Industrial Nurses' Association, etc., have viewed the Exhibit by this means.

Central Stations, Jobbers and Contractors are continually sending their prospects to the Exhibit. The installation of a large number of modern lighting installations in factories, stores, offices and clubs have been reported after a visit to the Lighting Exhibit. Hardly a day passes but what Jobbers or Central Station salesmen report the sale of new lighting equipment in establishments that have sent representatives to the Exhibit as shown by the register.

One instance of the far reaching results of an Exhibit of this type may be noted. A doctor retained by a number of the largest department stores in the east as a consultant in industrial hygiene, after viewing the Exhibit, was so impressed with the desirability of good lighting that he recommended that two of the largest Boston stores remodel their office lighting with the result that indirect systems of illumination delivering 10 foot-candles now replace the former drop cord systems. He is making similar changes in Washington, Philadelphia, New York, etc.

To date, approximately 1800 people have viewed the Exhibit and it is intended to continue this Exhibit indefinitely as the results have amply repaid the costs attached. At some future time it is contemplated changing the Exhibit to a commercial lighting one.

A Color-Organ Arrives

A COLOR-ORGAN called the Clavilux, an invention of Thomas Wilfred, will have its first public showing at the Neighborhood Playhouse, Manhattan, Tuesday evening. It is a delicate electrical instrument by means of which color and form moving in rhythm are projected upon a large screen erected upon the stage of a theater. The screen at the Neighborhood Playhouse will be made of ground glass. The organ will be behind the screen, and the color and form will appear through the glass to the audience, who will sit in a dark theater in which all is silence save for a low droning made by the machinery of the Clavilux.

As one short color composition after another is played to the vision the audience watches color in a gradation hues and values, change and fuse in harmony, first as field of pure color, then with the addition of solo figures, new forms created out of white light by mechanical means. These move in rhythm, constantly developing into other shapes, changing contour and color.

No music or other accompaniment, interpretation or explanation goes with the performance of the Clavilux.

The art of which the Clavilux is the instrument of expression is mobile color, not entirely new in idea but worked out by Mr. Wilfred on an individual and elaborate basis. He considers mobile color as a separate art, the great art which reaches the emotions through the vision as music reaches the emotions through the hearing. *New York Times,* January 8th, 1922.

PAPERS

USE OF LIGHT IN THE SURGICAL, DENTAL AND OPHTHALMOLOGICAL PROFESSIONS*

BY LOUISA PAINE TINGLEY, M. D., F. A. C. S.

On accepting your very kind invitation to present a paper before the New York Section of the Illuminating Engineering Society on the "Lighting in the Medical, Dental and Ophthalmological Field," I sent out one hundred and fifty enquiries to ophthalmologists, oto-laryngologists and dentists. It seemed to me that these specialists required the use of artificial light in their offices more than specialists in any other line of work in medicine. In answer to these one hundred and fifty enquiries, I received one hundred and twenty-nine replies, which showed the interest of the profession in the subject of illumination I also received several letters expressing the hope that something might be done toward the standardization of illumination, especially in the lighting of "Test Charts."

The following is a copy of the enquiries:

1. Do you use daylight or artificial light or combined lighting in your office?
2. If artificial light, what particular appliance do you use for such lighting, candlepower, style of lamp, etc?
3. What form of illumination do you use in the lighting of your test charts for distance?
4. What form of illumination do you use for the reading test types?
5. What illumination do you use for your ophthalmoscope and skiascope?

Questions 1 and 2 were sent to the oto-laryngologists and dentists, and all five to the ophthalmologists. I will first consider the answers received from the ophthalmologists, quoting from their own words:

*A paper presented before the New York Section of the Illuminating Engineering Society, April 14, 1921.

Question No. 1: Do you use daylight or artificial light or combined lighting in your office?

8 use daylight only.
6 use artificial light only.
45 use combined lighting, together or separately.
3 use gas.
56 use electricity.

Question No. 2: If artificial light, what particular appliance do you use for such lighting, candlepower, style of lamp, etc?

12 use indirect or semi-indirect lighting.
3 use gas filled tungsten lamps—100 to 300 watts.
8 use vacuum tungsten varying from 90 to 160 watts.
1 uses an "Ediswan with a gridiron filament, 230-32 mushroom shaped."
47 use direct lighting.
3 use nitrogen bulbs for ceiling from 100 to 200 watts.
1 uses "daylite" in all office apparatus, including desk light, 125 watts.
1 uses "prism 6 x 6 in treatment room."
1 uses 16-cp. with shade.
1 uses large tungsten ceiling globes 60 watts, full frosted.
38 use tungsten for ceiling and desk, size of units varying from 25 to 150 watts.
1 uses stereopticon, 100 watts.
1 uses a spot lamp.

Question No. 3: What form of illumination do you use in the lighting of your test charts for distance?

7 use daylight only.
6 use combined lighting.
46 use artificial.
2 use Meyrowitz cabinet reflected light.
2 use Hardy text cabinet reflected and transmitted light.
1 uses electric special cabinet reflected light.
1 uses special revelation cabinet reflected light.
1 uses cabinet with 6 concealed electric lamps, 15 watts each.
1 uses boxed type with electric lamps inside.
3 use flood lighting.
3 use transmitted light through glass.
1 uses transillumination of transparent paper with 60 watt tungsten lamp.
1 uses polished reflector placed at one side, two 25-watt lamps.
1 uses reflector tungsten lamp, 50 watts, at distance of 2 ft. from chart and one 25 watt reflector.
1 uses 140-watt electric lamp at top and one at the base of the chart.

1 uses a cone lined with mirrors containing 100 cp. lamps, set obliquely on the wall about 3 ft. from the type, one lamp covering the whole field uniformly.

1 uses reflected light from three angles to prevent perverse shadows.

1 uses "Frank parabolic reflector" with two opalite nitrogen 60-watt lamps.

1 uses "Frank semicircular reflector," with three 100-watt lamps.

Dr. Robert Scott Lamb uses "Ives" artificial illuminating white letters on a black ground and also the acuity test, and for his tests he is using a very dark room and mirror on the wall to get distance of 25 ft.

1 uses 8 lamps, ever ready tungsten, 15-watt, 115-volt. Lamps so placed that the light is reflected upon the card and not into eyes of the patient or examiner.

1 uses long electric lamps inside reflector.

1 uses 200 to 300-watt tungsten.

Dr. David W. Wells reports having tried "daylite" electric lamps, but found the glare from the cardboard unbearable. He now uses 40-watt tungsten lamps.

Dr. Frederic E. Cheney uses a reflector above the card with three 40-watt lamps.

1 uses two 60-cp. tungsten lamps 3 ft. from the test chart, with reflectors back of them.

1 uses electric lamps throwing light upon the chart from the front and side and hidden from the front.

1 uses two 50-watt tungsten lamps in reflectors.

1 uses four 15-watt frosted bulb lamps, one above, one below, and one on each side with a 6-inch tin reflector box above the chart.

1 uses 100-cp. "daylite" lamp, from above, concealed from patient.

1 uses frosted tungsten lamps behind translucent glass on which test letters are printed in opaque paint.

25 use electric lamps in reflecting devices placed at the side, above or in front of the test chart, ranging in strength from 16-cp. to 200 watts and 100 to 150 watts daylite.

Question No. 4: What form of illumination do you use for for the reading test types?

15 use daylight only.

44 use artificial light alone or combined.

1 uses inverted wall fixture.

1 uses 75-watt "daylight" nitrogen lamps.

1 uses a small flexible arm with a 15-watt tubular tungsten lamp, frosted and equipped with a small black metal shade.

12 use artificial light with 15, 25, 40, or 60 watt units.

30 use combined, frosted on brackets, desk lights, portable or light attached above patient's head.
1 uses frosted 3-watt nitrogen bulb above the patient's head.
1 uses "daylite" nitrogen lamp.
1 uses adjustable stand, ground glass 115-watt lamp.

Question No. 5: What illumination do you use for your ophthalmoscope and skiascope?

(a) For Ophthalmology:

Gas used by 5.
1 uses Welsbach burner.
4 use Argand burner.
53 use electric light.
1 uses 36-watt frosted lamp.
1 uses a round 16-cp. lamp.
1 uses a miniature frosted tungsten lamp.
1 uses special Nernst lamp.
1 uses 80-watt lamp.
1 uses 40-cp. frosted with Curry and Paxton bracket, power of reducing strength at will.
1 uses an opal tungsten lamp.
2 use an electric lamp with an iris diaphram chimney, so as to regulate the size of the aperture for skiascopy and ophthalmoscopy.
1 uses 30-cp. oculists' lamp on a bracket, frosted stereopticon bulb, with bulb's eye and tungsten filament.
1 uses an electric lamp with a white globe.
1 uses a round globe frosted, 25-watt lamp.
1 uses 40-cp. frosted lamp.
11 use frosted lamps of different sizes on brackets or stands.

(b) For Skiascopy:

Gas is used by 5.
1 uses a Welsbach burner.
4 use Argand burners.
43 use electricity.
1 uses a 25-watt special frosted lamp with a clear circle in the bulb.
Electric ophthalmoscope now used entirely by 28, and by others in conjunction with the reflected light ophthalmoscope, especially for bedside examinations.
11 use the electric skiascope of De Zeng.

The above answers show how dissimilar are the means used by the different ophthalmologists as a procedure for reaching the same end. Is it any wonder that the results obtained by one ex-

aminer do not exactly tally with those found by another? To my mind too intense light with glare is detrimental to all concerned. If its use is persisted in for months and years, it cannot fail to produce some harmful effect upon the eyes of the examiner.

I fear that there will not be any great improvement in the general lighting conditions of physicians' offices, until the plans of Professor Caldwell and other investigators have been worked out; namely, that the tenants may possess the lighting units. Under such an arrangement the lighting units could be easily transferred from one house to another, and not be as now, supplied by the landlord.

In offices of all physicians, irrespective of specialty three points should be considered as of utmost importance:—

1. *The light* as to whether daylight or artificial light will prove to be the better illumination for the examination of the patient; thus allowing us to detect the minutest abnormalities and pathological conditions. A steady light, free from shadows, must be thrown on the field of operation, so that the operator may not have his attention diverted by the necessity of adjusting the light.

2. *The illumination* should be of such a character as to permit the physician to do the maximum amount of work with the minimum amount of fatigue. Glare, or too high intensity of light, is as tiring to one's eyes and nervous system, as too low intensity, which latter condition blurs the field of operation.

3. *The patient* also should not be subjected to any unnecessary eye-strain by improper illumination, or too high illumination. As a rule a general lighting system of heavy density, semi-indirect units is highly desirable, as it is often necessary for the patient to lie down and it is very unpleasant to look at an open bowl or a semi-indirect bowl.

Consider first the reception room where the patients await the summons of the doctor; this room should be clean, orderly, attractively furnished, with comfortable chairs and soft colorings, with a table well supplied with current literature, subjects of interest to all. Curtains, if any, should be washable, so that they

may be kept fresh and clean. A patient entering such a room for the first time will at once imbibe the rest and ease which such a room offers. If possible, such a room should be light and airy, with windows facing the street, so that patients may have something with which to occupy their minds while waiting. Daylight is preferable to artificial light, except in the late afternoon and on dark days. The wall coverings should be of some neutral shade, which neither absorbs too much light nor furnishes glare. In choosing semi-indirect fixtures for such a room one must consider the height of the room, being careful to choose such a unit, or units, as will furnish equal illumination for persons sitting in all parts of the room without causing either shadow, glare or too low or high intensity of light. The illumination for such a room should vary from 5 to 15 ft.-candles, depending upon the size, shape and height of the room.

Ophthalmologists should have two reception rooms where patients may wait. The first room should be light for those, while waiting, who care to read or look out of the window, the second room should be semi-dark. In the latter room may rest the patients who are having their pupils dilated with a mydriatic, those suffering from inflammatory eye conditions, as well as patients having a mild congenital light intolerance. It is almost next to impossible to examine successfully this latter class of patients after they have been waiting in a brightly lighted room.

I think that physicians and surgeons agree that the use of strong daylight is essential for the general examination of all patients.

The consultation offices should be so arranged, that the physician sits with his back to the window, having the patient facing him and with the daylight shining upon the patient's face. He can then note the general expression, contour, color of skin and mucous membranes, condition of hair, hands, finger nails, tongue and throat, all of which are essential points in aiding diagnosis. The pupillary reflexes and general aspect of the lids and eyeballs, are better determined by daylight.

Daylight is used when testing the field of vision on the "Duane tangent plane," and for such minor operations as are done in the office. On very dark days, or in late winter afternoons, artificial light becomes necessary.

In Boston it is customary for physicians to hold afternoon office hours, and hence they are obliged to resort to the use of artificial light more than are the physicians of other cities who hold morning hours.

The walls of my consulting office are tinted very dark green with a wax finish, which gives them a soft light absorbing hue. The woodwork is dark mahogany. The three windows are protected by two sets of window shades; red on the outside, which are drawn from the top, and dark green inside, which are raised from the bottom. When these two sets of shades are drawn the windows are black, thus making my office almost light proof. The patient's chair is placed at the opposite side of the room from the test charts, a distance of 20 feet. For the illumination of my test charts for distance I always use artificial light, because it is uniform, and by the use of a standard illumination any change in visual acuity of the patient from one examination to another can be noted. The disadvantage of daylight is that it varies at different seasons of the year, different times in the day and under different atmospheric conditions.

The illumination of the test charts should be ot such a degree as not to affect the results obtained when the patient is subjected to a greater or lesser degree of light in his daily routine of work. I use a combined test chart illuminator and holder frame, (See Fig. 1) box shaped, painted black, 2 ft. 9 in. long by 12 in. wide and 3¼ in. deep. On either side is a prism receptacle of horseshoe shape, 4 in. by 3 in. overall dimensions, set at obliquity to the face of the card, 6 prisms in each side facing the card. I found that the six prisms cast too much shadow on the letters, and hence I painted the three on the same plane as the card, black, which removed the shadows, and now the charts have the appearance of being illuminated from behind by transmitted light. They have the advantage over those on glass in that one is able to change the card at will, using white chart with black letters, black chart with white letters, illiterate chart, etc. I use four 25-watt, frosted tip vacuum lamps, two on each side attached to the centre of the horseshoe with a projection of 1½ in. The lamps are 4 in. from either side of the test chart and 2¼ in. in front of chart. At the

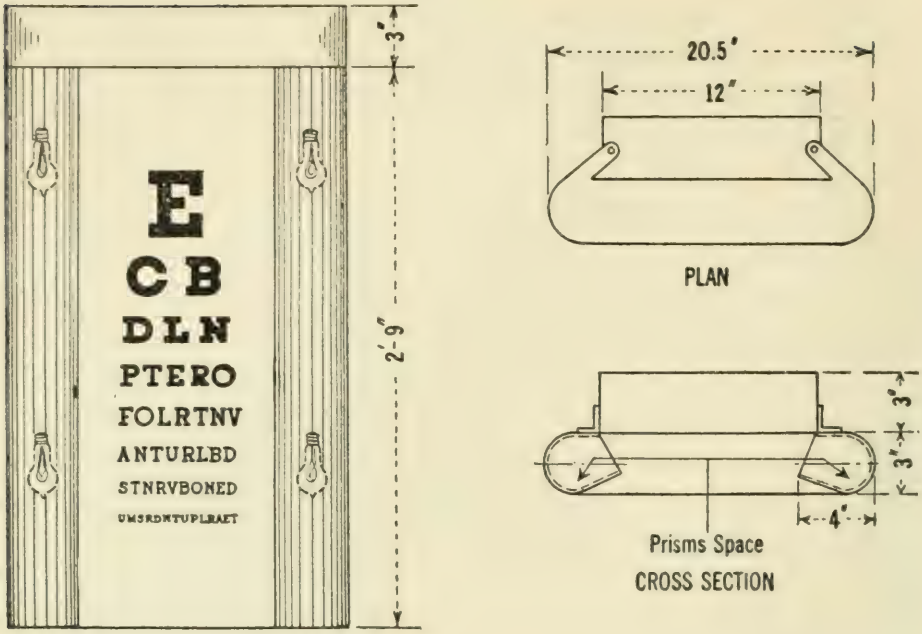

Fig. 1.—Illuminated Test Chart Holder.

top of the frame is a light tin screen painted black on the outside, with a projection of 4.75 in. This serves to reflect the light downward over the center of the test chart. The test chart holder is attached to the wall 3 ft. 6 in. above the floor. The patient, sitting on the opposite side of the room, is so placed that his eyes are on a level with the center of the test chart.

I have tried other forms of illumination for my test charts: box lined with mirrors with polished reflector at one side; (testing out bulbs of different watt capacity) also flood lighting; but I have found the test chart holder, first described, most satisfactory and least tiring to patients being examined. Patients often remark on the softness of the light and on how much less eye fatigue they experience by this method than when other type of reflectors have been used.

For the reading test types, I use an ordinary wall bracket, placed 34 in. above and to the left of the examinary chair, with an 8 in. tin reflector, painted white inside and black outside. In this I place a 25-watt type B lamp frosted. If use is made of too high an illumination for the test types, the glasses so prescribed are not

adaptable to ordinary working conditions. If a patient can see and be comfortable with a lense prescribed at a low degree of illumination, he will have no trouble in seeing with it if the illumination is high. I also use daylight for the reading test, the examining chair being placed with its back and side toward a window.

When taking the patient's history I ask the following questions:

1. The number of hours of continuous near-work done each day and nature of work.

2. Position of his desk and if it faces the windows.

3. If he works by direct daylight, or by daylight reflected from a glaring wall opposite his office windows.

4. Whether artificial illumination is used for desk or machine, and if so, as to whether light is direct, semi-direct or indirect.

In every case where the lighting conditions are poor in their homes or at their work, I offer suggestions for the betterment of such. I usually find that employers care more for the general arrangement and appearance of the desks and machines, and school committees for the position of the teachers' desks, than they do for the eye comfort of their employees.

For my ophthalmoscope and skiascope I use electric current; either a 4-cp. frosted carbon, or a 15-watt all frosted, type B tungsten lamp and a Loring ophthalmoscope. I use a De Zeng ophthalmoscope for bedside and home examinations. The light I prefer, but which I cannot have, because my office is not piped for gas, is that from the Argand burner, as the light can be raised or lowered at will. I use an adjustable double armed bracket which can be easily moved from one side of the patient to the other, when examining the right or the left eye, for both ophthalmoscopic and skiascopic examinations. For the removal of foreign

bodies from the upper lid and the cornea, I prefer daylight, but may use light reflected from a bracket lamp or the Wurdemann transilluminator with a cord attached to a wall rheostat. For all office operations I use daylight, if it is good; when not, a 25-watt or 50-watt type B lamp with reflector. The lamp suggested by Mr. Ward Harrison appeals to me, although I have never tried it. He gives the following description: "It is similar to a commercial floodlight unit, is equipped with a stippled glass lens mounted on a standard easily adjustable for height and mounted on rollers. This unit will provide high intensities for local work, the stippled lens producing sufficient diffusion to eliminate harsh shadows."

We will now consider the answers received from the oto-laryngologists:

Question No. 1: Do you use daylight or artificial light or combined lighting in your office?

25 use combined lighting.
3 use daylight only.
2 use artificial exclusively.

Question No. 2: If artificial light, what particular appliance do you use for such lighting, candlepower, style of lamp, etc?

4 use gas.
33 use electricity.
1 uses indirect lighting.
1 uses semi-indirect lighting.
35 use direct lighting.
1 writes: "Direct lighting is an extravagant luxury, semi-indirect is quite correct."
1 uses a MacKenzie condenser and Welsbach mantle.
2 use a Welsbach gas mantle.
1 uses an ordinary gas bracket, with gas chimney, because he can get the light from any angle, without changing the position of the patient.
1 uses a 100-watt tungsten lamp.
1 uses 60-watt tungsten Coakley lamp, "the most practical and least strain on eyes of any on the market."
1 uses 35-watt tungsten lamps for office illumination, with 40-watt tungsten lamps for reflected light in cavities, always frosted globe, re-inforced by large lens.

1 uses for general lighting a 100-cp. tungsten lamp, and for examination a plano-convex lens.
1 uses overhead circles of incandescent lamps which produce no shadows on the field of operation.
1 uses 25-watt lamps in a chandelier.
1 uses overhead cluster, ground glass, indirect lights and side wall brackets.
1 uses a round, frosted 60-watt tungsten lamp.
1 uses a 25-watt tungsten lamp, Mackenzie condenser. He prefers an electric head lamp for operating and ordinary head band for general use.
1 uses 75-cp. tungsten lamp.
1 uses 60-watt tungsten lamp with condenser lens in front.
1 uses a round plano-convex lens, 40-watt tungsten lamp in a Coakley laryngoscopic stand.
1 uses a 100-cp. ground glass lamp with a Coakley condenser.
1 uses a 100-watt stereopticon tungsten lamp.
1 uses a 50-cp. arc lamp.
1 uses a 280-watt stereopticon lamp.
1 uses a 40-watt Mackenzie condenser.
1 uses a 16-cp. tungsten lamp.
1 uses a tungsten lamp.
1 uses a round bulb, 40-watt tungsten lamp.
1 uses a Delavan portable lamp with a condenser lens in front.
1 uses 15-watt to 100-watt tungsten lamps.
1 uses 40-cp. tungsten lamps for examining the patient and various electric lamps for diagnosis.
1 uses 36-watt tungsten lamps frosted, with clear spot in the center.
1 uses a 50-cp. ground glass lamp.
1 uses a 100-cp. tungsten lamp with plano-convex lens for examination and operating.
1 uses a 25-watt tungsten stereopticon lamp with Coakley condenser with lens on a universal arm stand.
1 uses a 100-watt tungsten lamp and stereopticon, also a bull's eye lantern with a 100-watt tungsten lamp.
1 uses a Meyrowitz specialty lamp with condenser.
6 use the Coakley lamp with different size bulbs.

Here again we have a diversity of opinion as to the degree of illumination needed for the oto-laryngologists' line of work. I have permission from Dr. D. B. Delavan to quote his letter in answer to my letter of enquiry. Although an oto-laryngologist he treats the subject of illumination with full appreciation of the defects and advantages of present day lighting.

"Your subject is opportune and important. At some of our most important clinics the lighting arrangements are such as to inflict severe eye-stain. In many offices an *unguarded, white incandescent* lamp is used. Personally, I believe:

1. That the *incandescent* lamp is far superior to the old forms. (Gas, etc.)
2. *White* lamps are the most dazzling. *Blue* lamps are far superior—less trying to the eye sight, while they present the natural colors of the parts.
3. The exposed lamp is unnecessary and very dazzling. Some form of *protector* is a great saving of eye sight and an aid to the concentration of the light.
4. Of "condensers" that model invented by Sir Morrell Mackenzie, or some modification of it, is the best. I enclose a model of one of my own, made many years ago and used with satisfaction ever since.
5. In all of these the light is condensed by means of a plano-convex lens. In using the electric lamp it is *essential* that the light radiating directly from the films of the bulb be diffused. For the purpose of diffusing the light, I many years ago called attention to the fact that the *plane surface* of the *lens must be ground.* I claim to have first suggested this very important principle. Without its application the successful use of the light from the electric lamp is almost impossible.

I hope you will do something to educate the present generation, which seems to insist upon securing a maximum of eye-strain with a minimum of result."

I should like also to quote in part from one of the oto-laryngologists, who is also a member of the Illuminating Engineering Soceity, and who uses both daylight and artificial light. This specialist has had much more experience than I have had in the lighting of such offices in question, and has answered my enquiry more fully than other oto-laryngologists:

"As an ear, nose and throat specialist I use daylight as well as artificial light. First, however, daylight will be considered.

My office has been selected with these points in view. Direct sun rays are avoided and unobstructed skylight is used. That is to say, city chimneys, towers, or high structures are blotted out. In fact, a north light is sought, because the light is generally well diffused and more uniformly distributed. Furthermore, I have found the amount of light, as well as kind of light, less subject to variability at this point, namely, due north, than any other point of the compass. A dark green drop curtain of thick texture serves

at will to bar the admittance of too diffused light, and also renders negligible reflections from red brick walls or chimneys. The office ceiling is cream colored with a dull finish, and the walls are of the same color with a dull finish.

I now take up the question of artificial light. I use Dr. Coakley's light container with plano-convex or bull's eye lens. The apparatus is mounted upon an upright support. It is admirably adapted for office work of the ear, nose and throat specialist. It is simple in construction. It can be moved about easily by means of the physician's foot. It can be revolved in a horizontal plane, or in a perpendicular plane. Moreover, it can be adjusted to any desired height. The light in the container can be controlled at will by means of an electric foot-switch. The "Bryant" electric foot-switch appeals to me. A few of its strong points may be enumerated as follows:

a. The light can be operated in a cleanly manner.
b. The current can be turned on and off at will.
c. Several lines of operation can be carried on from a single line or socket.
d. There is less cost of maintenance.
e. When not in use no unnecessary light remains to annoy the patient or the physician.

In the Coakley container I prefer to use the 25-watt tungsten-filament lamp to the former carbon-filament lamp.

It is well to have an arrangement of wires by means of two systems. Then, if one fuse should blow out, the other source could be used. A change of plugs and cords would enable one to continue his office work with an imperceptible delay.

The ear, nose and throat specialist uses a head mirror with a central perforation, which serves as an outlook for the left or right eye. This mirror is made with a definite focal distance, it may be more or less than three decimeters. One may at will fully adjust the mirror, especially in reference to artificial light, as far as the Coakley bull's eye lens is concerned. Thus no light will be permitted to fall in the patient's eyes. The patient is most grateful for this added attention. From time to time it would be wise to make use of one eye and then the other, as far as the head mirror is concerned. In this way, one eye will not be over-exercised at the expense of the other eye."

The field of illumination in oto-laryngology has been so well covered by its members that it leaves little for me to say. The efficacy of the Coakley lamp seems to have been established.

Its simplicity of design appeals to me, and with intelligent manipulation of the lamp, the eyes of both the operator and patient can be well protected from glare.

I will close my paper with the replies of the dentists to my enquiries:

Question No. 1: Do you use daylight or artificial light or combined lighting in your office?

25 use combined lighting on dark days and winter afternoons.
4 use artificial light for late afternoons and evenings occasionally.
3 use daylight only, stopping work when it grows dim.
Northerly light is preferred by all but one, because it is freer from shadows. The single exception prefers southerly exposure. One wrote "all artificial light is a poor substitute for daylight."

Question No. 2: If artificial light, what particular appliance do you use for such lighting, candlepower, style of lamp, etc?

1 uses semi-indirect.
4 use indirect.
27 use direct.
None use gas.

Style of Lamp Used.

9 use Rheinlight.
1 uses Archer.
1 uses Phoenix.
4 use dentiscope.
6 use Bosworth or modified Bosworth.
1 uses Litch.
1 uses 75-watt blue daylight lamp.
6 use mouth lamps.
3 use head lamps.
1 uses a 50-cp. tungsten reading lamp with reflector, with small shield to protect the eyes of patient.
1 uses a plano-convex lens lamp with 50-watt light for reflected light.
1 uses a small electric lamp in the mouth.

As to lighting there seems to be less diversity of opinion among the dentists, than there is among the physicians.

Dr. Frederick E. Cheney, in answering my enquiries to opthalmologists, offers this valuable suggestion to dentists:

> "I would suggest that dentists using artificial light, would make many of their patients more comfortable if they had tinted spectacles for patients' eyes, not, of course, necessary in all cases, but light is bright for certain cases who have a mild congenital intolerance of light."

I may add that such glasses might be worn to advantage also when the daylight is strong and bright. It is well to bear in mind that such glasses should be carefully disinfected after use, thus carrying out the principle of sterilization of all instruments.

My criticism of most of the lamps used is that they are of too high intensity. The position in front, or to the side of the patient, where the lamp is usually placed, so as to illuminate the field of operation, must of necessity result in a great strain on the eyes and nervous system of the operator, as well as of the patient. I may mention here that an operator who has continually to adjust a lamp, cannot keep his hands sterile. Such a procedure is contrary to all present day teachings of surgical technique.

As the dentist's practice is confined mostly to office work, he starts his working hours early in the day, and, unless an emergency occurs, he can ordinarily cease work when daylight becomes insufficient for his requirements. Probably for this reason he makes more use of daylight than of artificial light. This fact seems to have been borne out by my statistics. Unless the small area in which the dentist works is well lighted, many tooth cavities may be overlooked and work improperly done.

The work of most of the ophthalmologists, oto-laryngologists, and dentists, is a great tax on the eyesight, and hence the daylight and artificial light used by them should be made as perfect as possible.

I understand that much is being done at Nela Park, Cleveland, O., and the Edison Lamp Works, Harrison, N. J., on the subject of the illumination of dentists' offices, and they have in use certain lamps which remove the objectionable features of glare and shadow.

The above statistics and suggestions which I have brought before you may pave the way for further investigations by members of the Illuminating Engineering Society, and help, at least, to form a basis for the standardization of the illumination of Snellen and other test charts, and thus serve for the better illumination of all physicians' offices.

We admit that cost plays an important part with many physicians. They desire adequate illumination, but often look upon it as one of the things they can do without.

As you doubtless perceive, the trend of my paper has been toward the conservation of vision, which is sometimes lost sight of in our desire for greater light intensities. The main thing is to secure the most efficient illumination with the least eye-strain.

DISCUSSION

The papers by Dr. Tingley, Mr. Maijgren, and Dr. Russell were discussed together. See page 35.

SURGICAL LAMPS*

BY THORVALD MAIJGREN**

The history of the surgical lamp is really a history of modern diagnosis and treatment. Before its advent physicians had to rely upon the head mirror giving a reflected light, and which could only be used for surface diagnosis or for a cavity sufficiently large to allow of surface examination.

The first real surgical lamp utilized was for the urethroscope. Previously a certain type of considerably larger size had been used for mouth and throat examinations. This lamp really did not accomplish any better result than the older method obtained through the reflected light of the head mirror and could not be classed as a surgical lamp as it really was nothing but an ordinary toy lamp such as used in those early days and which was attached to a tongue depressor and offered to the physicians as a mouth illuminator.

In the year 1898 a wandering electrician named Preston called on the physicians in the city of Rochester offering a mouth lamp such as the one just referred to and happened to meet Dr. Henry Koch, a genito-urinary surgeon, who frankly told Preston that his instrument was of little or no value to a physician, but stated that if he could produce a lamp of limited size and comparatively cold it would probably be useful and would fill a need long felt by the profession. Mr. Preston stated that he would try, and after considerable experimental work under the direction of Dr. Koch he presented a small flat lamp, measuring about 8 mm. in length, 3 mm. in width and about 1.5 mm. in thickness. This lamp was attached to an urethroscope designed by Dr. Koch and thus the first surgical lamp and first electrically lighted surgical instrument was constructed in this country. It is proper to state without going any further that the surgical lamp used in connection with the cystoscope had been made and utilized in Germany a few years previous to this time, and for this due credit should be given to Dr. Nitze of Berlin. This lamp, however, was so large and

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**The Electro-Surgical Instrument Company, Rochester, N. Y.

radiated so much heat that it could not be used for the urethroscope and not in the bladder except in connection with water dilatation, that is with the bladder filled with water, to modify the heat radiated by the lamp. The Preston lamp with the Koch urethroscope was a decided advance in the surgical field, as previous to this time the only source of light that had been utilized in the urethra was a heated platinum wire used according to the Oberlaender method of illumination. This method was both dangerous and unsatisfactory, owing to the great and constant danger of burning the patient. The great pain caused by the heat and the necessarily large amount of current required for heating the platinum wire were serious disadvantages. Furthermore, the light was so limited and so uncertain that comparatively poor results were obtained when utilizing this method for treatment and the diagnosis was most uncertain. Thus the surgical lamp as produced in this country brought a great revolution in the field of surgery. The American lamp was superior with regard both to size and utility. This was proven by the fact that for many years physicians who went abroad and purchased French and German cystoscopes, upon their arrival in this country purposely removed the foreign lamps from their fittings and substituted American lamps because with the latter they could obtain more light with less current and the heat was so much less that they could use them either with water or air for dilatation when examining and treating diseases of the bladder or catheterizing the ureters.

So great was the enthusiasm created in the medical profession by the Koch urethroscope that it was immediately taken up by the leading physicians and surgeons in their different special branches. The proctologist found the surgical lamp, when properly utilized, of immense value in his work. The proctoscope and the sigmoidoscope, when equipped with a surgical lamp, became instruments through which a heretofore unseen field could be explored, diagnosed and treated. He could with the sigmoidoscope, without injury or even discomfort and without an anaesthetic, explore the entire rectal cavity from the anus to the sigmoid. This achievement was of the utmost value, as an early and a certain diagnosis and immediate treatment in this particular field of surgery is of the greatest importance and has

been the means of saving thousands of patients from a life of dreadful suffering and an early death.

The bronchoscopist was not slow in utilizing the opportunities offered by advantages afforded by the surgical lamp and the result has been a complete revolution in this field of work. With the specially constructed instruments, of which the lamp is the most important part, he has entered into and explored the oesophagus, even extending his exploration into the stomach. The trachea as well as the bronchi have been entered, explored and treated. Untold lives, particularly among children, have been saved through the pharyngoscope and the bronchoscope, as foreign substances such as safety pins, buttons, coins and even artificial teeth, etc., have been removed from the trachea and the bronchi through the instruments mentioned and with the aid of specially constructed forceps. A considerable amount of experimental work and great mechanical skill and ingenuity have been exercised in constructing these instruments. They have enabled the surgeons to enter the lungs and drain abcesses, remove foreign bodies and cut away obstructions on the living patient. These operations could never have been accomplished but for this surgical lamp, as it has, so to speak, shown the way at all times during the exploration and during the work in the passages and organs referred to.

Many instruments, too numerous to mention in this paper, have been successfully constructed and tremendous advantages obtained by the use of the surgical lamp, but I consider the nasopharyngoscope to be so far the crowning success of these achievements. This instrument is equipped with optical lenses and a prism forming a periscope so that by turning the instrument the surgeon has an illuminated view in every direction When it is introduced through the nostril a well illuminated view of the interior of the maxillary antrum may be obtained, the opening of the eustachian tubes can be seen and a clear and well defined view of the larynx, as well as of the vocal chords is presented. Never had it been possible to see these various internal organs and cavities accurately except during post mortem examinations and the results obtained by the use of the sigmoidoscope, bronchoscope and cystoscope are nearly as remarkable.

I take it for granted that all wish to know what further progress can be obtained and what further improvements can be made in connection with the subject of electrically-lighted surgical instruments and the utilization of the surgical lamp. It is safe to say that the principal progress in the future will be accomplished in the way of transillumination through stronger light with greater penetration into the various tissues of the living body. A promising field for this kind of illumination is undoubtedly the higher transillumination of the region of the frontal and other nasal sinuses and also possibly a better transillumination of the digestive organs probably by the method of inserting a powerful lamp through the oesophagus into the stomach and thus observing the pylorus and duodenal region from the exterior when obstructions prevent the introduction of the gastroscope.

The principal feature of electrically-lighted surgical instruments of the scope or tubular variety is that they be made as small in calibre and with as large a light output as possible. To obtain this result it is important that the circuit carrying the lighting current take as little room as possible and of course be so concealed and protected that blood or other fluid cannot reach it to cause short circuit or any other disarrangement.

In conclusion I wish to assert that in all human history no lamp ever invented has contributed so much to the welfare of the race, has done so much to alleviate suffering and preserve human life as the surgical lamp. I wish also to pay my tribute to the noble medical profession whose patient and unselfish devotion to their calling has made these wonderful results possible.

DISCUSSION

The papers by Dr. Tingley, Mr. Maijgren, and Dr. Russell were discussed together. See page 35.

ARTIFICIAL LIGHTING IN DENTISTRY*

BY DR. PERCY RUSSELL**

It has already been pointed out that there are several branches of the healing art whose workers need special lighting for their operations. The general surgeon, the eye, ear, nose, and throat specialist, and the dentist, (to mention only a few), have problems which differ very much among themselves, and differ from the problem of the general illumination of reading rooms, reception rooms, retiring rooms, lobbies, stores, etc. It may be that our nearness to the problem makes our own difficulties seem great, but I think we are safe in saying that the problem of the dentist calls for as much ingenuity on the part of illuminating engineers as does any of the others. Illuminating engineers have of course, mastered the principles of illumination in general, and, in so far as the commercial interests with which they have to deal have been willing to adopt their views, they have admirably succeeded along many special lines. But in the dental field they have perhaps not as yet been sufficiently encouraged to embody their knowledge in useful apparatus.

One reason for this is that up to the present the business manager has been too often the operator himself, which means that having his own physiological, anatomical, surgical, and other problems uppermost in his mind, he has been unable to give sufficient attention to the lighting of his operatory or the construction of illuminators. I believe this is indicated by the fact that hospitals in which the surgeon and the manager are different persons, are better illuminated than dental offices in which generally the manager and the operator are the same person. So it has been left too largely to the dental manufacturers to work out the problem of lighting in dental practice, and these men have not been in as close touch with the illuminating engineers as they ought to be and have not generally so analyzed the dental problem as to be in position to avail themselves intelligently of the available knowledge; and they have failed in great degree to acquaint the

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**The Electro-Dental Manufacturing Company, Philadelphia, Pa.

illuminating engineer with the peculiar problems in dentistry which might long ago have been solved if parties could have been brought into team-work relations.

We are safe in saying that some dental offices are well illuminated by natural light when the weather is most favorable. Such an office is provided with a large window extending to a high ceiling, looking out upon the north side of the building, with a sky-area entirely unobstructed. The walls of the room are white or nearly so, from the ceiling down to the wainscoting, and the ceiling is white. The floor and wainscoting are darker colored. On a clear day the deep blue sky floods the interior with light of very good quality. The bracket table and the mouth of the patient are well illuminated, not only by the direct light from the sky, but by that which is reflected from the ceiling and walls and the operator's white uniform. However, there are many offices whose windows have a poor outlook upon the sky, and often the skylight itself is poor, or gone entirely. Then the operator needs an illuminator capable of flooding the office with the same quality and quantity of light that comes in from the unobstructed sky-area on a bright day.

Moreover, there are certain operations in the mouth, the proper performance of which requires even more light than this. It must be remembered that the surfaces of the teeth with which the dentist has to deal, (much more frequently than with the soft parts), face in all directions, some of them backward. Remember too, that the lips and cheeks have a way of limiting the direction in which the light can enter the mouth, as well as the position of the operator's eyes. When a cavity opens toward the rear, the dentist is forced to use a reflector to catch some of the skylight, direct it into the cavity, and at the same time hold his eyes in position to receive the returning rays. Sometimes this is easy but occasionally the operator's head most obstinately cuts off the incoming light, leaving the cavity in semi-darkness. Then, since neither the skylight nor that from the illuminator, to make use enter from outside, it is necessary for the operator, to make use of a lamp.

Much effort of an empirical rather than scientific sort, has been made to provide the dentist with satisfactory lamps of those

two forms; these being the two original phases of the dental lighting problem. But there is a third phase of the problem which has some very different characteristics.

There is a comparatively large cavity in the bone of the face; a cavity below the eye socket, to the side of the nose, above the first molar tooth, let us say. This cavity opens into the nose and sometimes becomes infected from the nasal passage. Then again, at times the roots of some of the teeth enter it and, in certain conditions. there are discharges into it from the teeth. In these, and other cases, it may become a breeding place for such quantities of microbes that the whole cavity becomes filled with malignant pus. Such conditions are very serious and sometimes have continued for months without either physician or dentist being any the wiser, when neither one possessed ready means for making quick examinations.

This cavity can be examined by light projected through its surrounding bony and fleshy walls, and for this purpose another form of illuminator is needed. This form is called, after the abbreviated name of that cavity the "antrum lamp" (though it is also used elsewhere) and it must emit a very bright light. During the past fifteen years considerable effort has been made to provide a more satisfactory bulb for this illuminator, and it has been somewhat improved.

We have before us then, for consideration, three forms of dental illuminator: first for general lighting to supplement daylight, or take its place entirely; second to generate light within the mouth for viewing *surfaces* by light *reflected from them;* and a third, to generate light within the mouth for viewing tissues by light *transmitted through them.*

These three forms of illuminator being required to function very differently, of course, differ greatly in size, shape, power, brilliancy, method of application, etc. Before the advent of the incandescent electric lamp, form A was represented by a gas or oil lamp with a reflector behind, and sometimes with a water-filled lens in front. Later, when the electric bulb took the place of the lamp, the reflectors and lenses and housings were experimented with a great deal, and some progress was made.

Then it was suddenly discovered that everybody had been working in the wrong direction; that no matter how good this

form of apparatus might be made it would still not be well adapted to its purpose. This happened about sixteen or seventeen years ago when Dr. M. L. Rhein, a dentist of New York City, had made for himself a 4-lamp cluster, fitted with prismatic, diffusing globes, but without lenses. It was then seen that the old spot-light principle was wrong; that the light needed to come from a large area in order to convert the formerly troublesome umbras into the now almost disappearing penumbras; that this object was best accomplished by an illuminator which allowed much light to escape in every direction so as to illuminate up the whole room and its contents, and that this also resulted in saving the eye strain due to the former necessity of gazing alternately at brilliantly and poorly lighted objects. Our ideal now it to illuminate the operating room artificially exactly as a perfect and unobstructed sky does it naturally. It would seem to be possible to arrange lamps, reflectors, diffusers, absorbers, and what not, in such a way as to provide the needed quantity of light, having the right chromatic qualities and devoid of the wrong thermal qualities, a so-called white light is undoubtedly preferable to work by.

It seems that when the dentist is provided with enough light its color is poor, and there is too much heat with it, while when we try to give it to him of the right color, there is not enough of it, and yet the heat is still greater. This is a condition which it is very desirable to remedy.

Now let us consider the two small intra-oral lamps, the forms I have called B and C.

Form B is mounted in the handle of what the dentist calls a mouth mirror; that is, it ought to be in the handle and we bluff ourselves into thinking it so; but really the lamp is in a separate housing of comparatively large dimensions with the mirror handle strapped to the side of it. This combination is made in various designs by different manufacturers, each one with some good points and some poor ones. Some are strong and heavy like ours, some slender and weakly constructed; some easy to take apart, others too brittle to be practical, and so on. Not one of them is right in all respects, most of them are wrong in several respects, and all of them wrong in at least one respect—the color of their light. Of course, the lamp makers are not directly responsible for the mounting of their lamps, but indirectly they are.

Give us small, cool, durable bulbs at a reasonable price and we flatter ourselves that we can build electric mouth mirrors of very decent smallness and sell some, even though their light is yellow, but if the bulb makers can go further and make them emit a white light and still run cool, we will sell many more of them, and they will not only be a credit to you and, by contiquity, to us, but will be a boon to both the dentist and the patient, because of the strain removed from the eyes of the former and the better service received by the latter. This is no idle fancy but a practical need in dentistry. The operator can only do justice to his work when all the tissues are clearly seen. Had the eyes of man been developed evolutionally in the yellow light of our present day lamps, then no doubt we would all be able to see better by yellow than by white light, but thanks to our old mother nature who kept us away from artificial lights while the race was young, we became so accustomed to seeing by sunlight that light of this character is best for us.

The form I am calling C differs much from B in relative size and power. While one to two candlepower is ample in B for surface lighting in the mouth, the trans-illuminating lamp C must develop 20 cp. or more in order to be satisfactorily effective and this must be projected in a narrow beam through an opening in the side of a hood. The bulb could be as large as 0.5 in. in diameter and 1 in. long, or it might be a 0.75 in. sphere,but it must run reasonably cool without the clumsy jacket and tubes that have been tried for carrying off the heat by water or compressed air. And I ask whether for trans-illuminating teeth gums and bones, the light ought to be white. We find that partial blanching of a tissue, for instance, driving the blood out by pressure. allows freer penetration of the yellow rays we use at present. This makes an enormous difference in the effectiveness of a lamp. A lamp which could be handled in this way within the mouth, for twenty or thirty seconds at a time, together with a properly shaped transparent applicator pressed against the face to drive the blood from the surface tissues, would add immensely to the value of this method of antrum examination.

One must not forget that while making all this adaptations, the lamps for intra-oral use must "boilable." The human mouth in these days of mushy, deficient foods, physically and

virtually denatured, has become such a veritable inculator for serious communicable diseases that it is unsafe to carry material of any kind from one mouth to another except by way of the sterilizer. Any illuminator used in the mouth must be so built as to come apart easily, and the separate parts must be uninjured by "boiling" and be easily dried before putting together. It is sometimes said, in extenuation of this disability of the commercial lamp, that it is not necessary that the lamp bulb should come into contact with any part of the patient's anatomy, and hence that it can be used so as never to need sterilizing. This may be theoretically true, but it is not always practically possible. Until so made, they will not satisfy the dentist nor will they inspire confidence in the dentist's patients. In the only safe dental office routine the whole armamentarium is handled in such a way that the operator would be willing to accept his little daughter as a substitute patient at any time whatever, without wishing to take any extra precaution.

Now, after this general review of the three phrases of the lighting problem in dentistry, we might summarize each phase ideally thus:

Form A. An illuminator capable of generating a light so closely simulating the blue, north-sky light that if gradually turned on while a black curtain gradually shut the daylight completely from the room neither the operator's eye nor the photo—now the chromo—nor the thermo meters would detect the difference.

Form B. An electric mouth mirror of one to two candlepower, emitting a white light without heat ;all parts "boilable." The bulb being not more than three-sixteenths of an inch in diameter, having good life, and being of reasonable cost.

Form C. An intra-oral trans-illuminator for the teeth, bones of the face and jaws, emitting 20 to 30 cp. without heat; all parts "boilable," the bulb being not more than 0.5 in. in diameter by 1 in. long, with good life, and of reasonable cost.

Of course one must not expect to realize this ideal immediately, but in view of the very serious shortcomings of present illuminators of all three forms, it is hoped that something good is now about ready for us along the line of the most important and most difficult points, namely heat and color, size and cost.

DISCUSSION

Dr. M. I. Schamberg: This is an intensely interesting subject particularly to professional men. There are a number of distinct problems that are brought up and the subject is almost too large to cover in every detail.

Another phase of the subject is illumination in instruments for surgical rather for various medical purposes, as the instrument for illumination of cystoscopes. That, however, is a distinct field in which the instrument maker is more concerned than the illuminating engineer.

There is another phase of lighting, however, that is highly important and that is the illumination of the cavities of the body, the mouth, the nose, the ear, the abdominal cavity, the external dental parts and the rectum, which require certain types, as a rule, of projected light.

My work is within the mouth. I have been working with every type of lamp that has come out for a number of years and have finally developed something which I believe is a distinct innovation in lighting. I brought one of the lamps with me this evening but I do not want to impose myself upon you unless you care to see it.

It is a series of mirrors made out of blue glass so as to absorb the yellow rays but as nearly as possible to imitate the white light of daylight. The lamp is arranged in such a way that you can project light into the mouth, the ear, the nose or any part of the face without striking the eyes of the patient.

I was rather impressed with the statement of the first paper where it was mentioned that when patients are exposed for some time, as they are in the dental chair, to intense light their eyes should be protected. I think that the day will come when dentists will work very much like nose and throat men entirely by artificial light because it is more uniform, you can get a uniform illumination of a definite degree of intensity, whereas daylight is variable.

The Lord evidently intended that we should stand the strong rays of sunlight otherwise we would not really have such intense sunlight as is occasionlly our good fortune to see upon a clear day and yet we would not care to use that sunlight either for reading purposes or for close work. You would not care to read a newspaper in the sun, but there might be another piece of work in which every bit of daylight available would be of use. The

gradations of light must be governed by the type of work at hand; and in the past we have been endeavoring to work in the mouth with insufficient illumination and I think there is not a dentist who has not been straining his eyes, because of this fact, while he is doing work on the mouth.

For a year and a half I have been working with a lamp which I devised for this purpose which enables me to keep my operating chair at some distance from the window. Daylight is used to illuminate the room and this lamp projects the light into the mouth directly upon the part that is to be used for operation.

This lamp has attracted quite a little interest on account of its unusual makeup and I am more interested in having you see it because no description is quite the same as seeing the lamp itself. This one happens to be in a light weight casing.

The Edison people maintain that the 100-watt stereoptican bulb is not guaranteed for 100 burning hours and it appeared to be one of the great drawbacks of the lamp until we devised a system of ventilation which has enabled me to use one of these bulbs for a year and a half without changing. They also claim that the bulb must be burned in the erect position. We have burned it in the horizontal and oblique position. At first before we adopted this system of ventilation by means of this air chamber between the shield which protects the eye from the direct rays, we found we burned out every socket to which we applied this bulb because the lamp reflected the light and heat back of this socket. The principle of this lamp is the reflection from the part of the bulb upon a series of mirrors, you can see the rays emanating from the mirrors projecting forward. With this lamp we produce an illumination of the oral cavity without the eye strain of the operator or the patient because we can direct the light immediately below the level of the eye.

Dr. H. L. Lynah: I have been interested for some time in this illuminating business especially so in the bronchoscopes and the laryngoscopes. In the work in that line, there is used a reflected light source that directs rays in such a way that you can see some distance but the great difficulty is that the patient coughs and clouds up the mirror. In the instruments made by one company, they have devised a method which gives sufficient illumination far down in the lung or in the stomach. With those in-

struments, it is very easy to remove secretion so that you do not lose any time.

Somebody may ask how about secretion of the patient coughing out constantly. The operator must have a number of bulbs at the side and one nurse is employed to keep the bulbs clean and they are taken off and on.

WARD HARRISON: Recently we spent a considerable amount of time in developing a lighting unit for a throat specialist and succeeded in producing one that was very satisfactory. This particular unit is an application of the ordinary floodlights which have been developed during the war. It consists of a flood lighting mirror about 18 inches in diameter and is equipped with a daylight lamp. A powerful beam can be directed toward the patient. A diffusing front cover glass was used to eliminate striation and spread the beam somewhat.

The unit received very favorable expressions of opinion from a number of surgeons beside the one for whom it was developed, and it seemed to us that a projector of this type should be made widely available. However, we have been unable to find anyone who would attempt to place it on the market because the commercial difficulties are so great that the party who took it up probably would not secure a return on his investment. This is a sordid viewpoint but one that must be met eventually in every development of this kind.

L. C. PORTER: Dr. Russell pointed out some very logical lines for improvement in both dental and surgical lamps, and as a lamp manufacturer, I should like to bring up a few of the ways in which some of the surgeons, dentists and manufacturing concerns can assist the lamp manufacturer.

Two of the points which Dr. Russell brought out were these — the necessity of a lamp which would generate less heat and of a lamp with whiter light. There have been rapid strides made along both of these lines. In going from the carbon filament lamp to the tungsten filament lamp, the latter has very largely reduced the heat. I think there are possibilities of going still further. Of course, the heat is more or less tied up with the efficiency of the lamp, and the efficiency of the lamp is tied up with the life; the shorter the life, the more light one can get out of it in proportion to the energy which you put into it.

On the question of color, it should be possible to build some of these small surgical and dental lamps with a type of glass similar to that used in the larger lamps for color matching purposes, in other words, some of the daylight blue glass.

I think the lamp manufacturers owe it to the general public to look into this subject and see what can be done to improve and develop the general line of lamps for surgical and dental work, and I am very glad to say there is already under way a movement on the part of lamp manufacturers to do this.

In the past, these small lamps have been developed as people wanted them and nobody seemed to know what they did want. One manufacturer would want a lamp that he could operate with a certain size dry battery. Somebody else would want a lamp to be operated in series with a resistance. Another fellow had a bright idea to put his lamp on a little transformer. Under such conditions, it is almost impossible to develop the best lamp of this type.

In going over a list of surgical lamps that we have been called on to make during the past two or three years, we found there were some eighty different types of surgical and dental instrument lamps. Many of them vary from each other by small differences; differences in the base, or voltage, or other very minor differences. Under those conditions it is not possible to carry lamp development to the highest efficiency.

It would be of tremendous value if the manufacturers of surgical and dental instruments would get together with the lamp manufacturers and standardize a small number of lamps. I believe six or eight lamps could be developed to fill the demand.

The following lamps would probably meet a very high percentage of the surgical and dental lamp field:

Volts	Amperes	Bulb
1.5	0.30	T–¾
2.4	0.10	T–¾
2.1	0.29	T–1½ — tipless
2.1	0.29	T–1½ — lens end
2.1	0.29	T–2½ — tipless
8.0	0.70	T–3½ — tipless
6.0	0.28	G–3 — tipless
3.0	0.90	G–5½ — tipless

If the manufacturers would standardize on the lamps, it would enable us to do greater research work in developing the light sources.

Another thing that should be standardized is the bases. In the past, the surgical and dental instrument manufacturers put out bases which they had designed possibly through lack of anything better to use and also with the feeling that in having a special base they would in that way control the renewal product. In the long run such practices hinder the general development of the best type of lamp for this class of service, and tend to limit the sale of the instrument using such lamps. Bases should be standardized so that the lamps would be interchangeable. Such a plan would allow a wider distribution of lamps, and would reduce manufacturing costs, facilitate deliveries and improve quality.

Dr. M. W. Ware: I came here for the purpose of getting information myself. I have listened to the various speakers and it has opened up my mind to the fact that it is not the question of the light but it is a question of the man behind the light. We have had instances of operations under candle light and oil lamps.

But there is no doubt in my mind that use should be made of some sort of concentrated light. One cannot do effectively detailed work with diffused light. The anology of the watch maker I do not think holds. He works in the daylight. He has his monocle and magnifies the object on which he is working.

Miniature lamps to illuminate the interior of the body have engaged my attention a great deal. When we get into the lung, we do not walk in, but Dr. Lynah knows what we can do with the lamps. We look into the tube and judge things as they are in the lung by its appearance through the orifice; just as you may judge a man has a cold by seeing that the orifices of his nose are red.

We are not so insistent upon the life of the lamp. We are extravagant, we physicians. We have not the sense of proportion with regard to the mechanics of it. Dr. Lynah has said correctly that we should always be provided with two, three or more of the bulbs because accidents may happen.

I take issue with the gentleman who stated that one of the requirements of the small miniature lamps was disinfection by boiling. It is not necessary to boil such an instrument because the

water would get into cement and destroy it. Nor is boiling necessary because the severest test of those lamps is where in the case of tuberculosis we have the lamps inside the bladder for nearly an hour especially where you have to do extensive manipulation. In such cases the lamp is contaminated and the question comes up how are you going to do the disinfection. We have other means than boiling. If you wipe that lamp carefully with pure carbolic acid that will not affect the mounting and you have an effective way of disinfecting.

The lamps very frequently become soiled by blood. One must remove the carrier and replace it. The blood can then be removed by applying a little peroxide of hydrogen which will immediately cleanse the lamp.

G. H. Stickney: One might, on casual consideration, expect to find more adequate lighting in hospitals than in dental offices. Our investigations seem to show that the reverse is true. The explanation seems to be, first, that the dentist applies his eyes closely for longer periods of time, and therefore, must expend more severe visual effort. Again, good lighting is of direct commercial value to the dentist, while in the hospital there is a division of authority, so that the surgeon cannot always secure lighting which he might prefer.

In regard to the practice of lighting in dental offices, we have noted an increasing use of special illumination for certain instruments and conditions. On the other hand, there is a much more marked tendency to provide strong general (or localized general) illumination, often of the semi-indirect type. Such units are located with reference to the chair, so as to apply the direct light most effectively.

The hospital operating table should be provided with the best possible lighting. A practice which we have found desirable, is to locate the units—six or eight in number—in a circle of about 8 ft. radius, about 12 ft. above the floor. By means of reflectors, the light from these several sources is projected on the operating table beneath the center of the circle. As the light comes from several directions, shadows are minimized and a good penetration secured. It is well to have one of the lamps adjustable as to height and direction for operations requiring a horizontal component of light.

The possibilities of dust falling in the wound is minimized since the individual lamps are not high heat generators and are not placed directly above.

White light is especially desirable where it is necessary to distinguish small veinous and arterial vessels by the difference in color. The color discrimination is more readily made with the so-called daylight tungsten lamps than with the regular type, since the yellow tinted light tends to reduce the contrast.

I believe that the dentists' demand for whiter light comes largely from the desire to match artificial teeth more accurately, as a matter of appearance.

Light from the daylight tungsten lamp is a practical compromise between that of the ordinary tungsten lamp and north skylight, and is scarcely sufficiently accurate for exact color matching of teeth. For this work, it is, of course, desirable to secure a reproduction of north skylight by the means of special color plates, used with gas-filled tungsten lamps, which absorb a larger proportion of the light but give the result sought for as to accuracy.

S. E. Doane: I want to congratulate the New York Section on arranging this delightful evening. I think the Society ought to be complimented in bringing the men together who are so well known on all phases of this subject.

I would like to ask if the doctors have any recognized Standardizing Committee or other procedure that, if a standard were agreed upon, the individual manufacturer could be induced to adhere to it. I want to say to the doctors that we are proud of the very complete standardization of our industry. The manufacturers adhere to the standardized lines very closely. We have accomplished this through cooperation. A base of any acceptable design properly standardized will be a good thing. If the doctors could arrange some program in which we could cooperate, the standardization would be easy indeed.

P. S. Bailey: One of the speakers mentioned, in the early part of the evening, a flood-lighting projector which he had tried in connection with surgical operations in several hospitals and as I am rather interested in that subject, I would like to carry away with me a definite idea as to whether the device really has a practical value. I think, perhaps, some one of the surgeons present could give me a definite statement.

E. L. Sholl: Will one of the doctors present state what constitutes a warm light, in Fahrenheit degrees. What could the interior of the lungs endure in the way of temperature?

Dr. Percy Russell: An important point for all of us is the matter of standardization, the dental manufacturers, the manufacturers of surgical lamps, of all kinds and the manufacturers of the bulbs. This will involve the eliminating of as many forms as possible and arriving at a compromise that will enable all of us to use as far as possible the same size and shape of bulb with the same base. It would have to be a compromise from all sides. It would involve radical changes in the apparatus used to operate the dental and surgical lamps and it might involve some changes in the manufacturing procedure. It seems to me if a conference could be arranged among ourselves, that we could do some preliminary work together and then go ahead in some way or other and get somewhere. The object of my paper, the conscious object of it, was to bring that about by putting before you some of the problems that we dental manufacturers have.

Dr. M. W. Ware: We have a woeful lack of standards. There is not any such committee of standards and I can go farther and forsee some of the great difficulties because the shafts in these instruments vary so much and there are so many gradations that one would have a base with a thread screwed in an inch and another would have it a different way.

I came down to learn something about the cystoscopes. To-day cystoscopes are made better in America than in Germany. Those shafts are standardized in this sense that we have adopted the French system of scale for calibrating. They build them in two sizes one for the child and the other for the adult. But even then there a great variety is made.

To show where the difficulty comes in let me say that when those lamps are burned out one has to wait two or three months before you can get another.

Non-member: I would like to say that 110 degrees Fahrenheit is considered a warm light and below that would be considered a comfortable temperature for the body.

As an engineer I realize the necessity of the standardization of instruments. We engineers have standarized our scales and our instruments. But we have heard about the necessity of standardi-

zation among instrument men. I think if the instrument men would take this matter up with the American Medical Association and not with isolated groups, we could get better results.

In regard to the cystoscopes, many people are accustomed to one kind and will not use another, still others have bought one and do not want another. If this matter is taken up with the American Medical Association, it will give the instruments some prestige, the prestige of the American Medical Association. I think that is the best way for you men to get at it.

I can appreciate these problems from the point of view of a former engineer and I take pleasure in offering you these recommendations.

Dr. Alice G. Bryant (Communicated): The subject of the paper, "Use of Light in the Surgical, Dental and Ophthalmological Professions" is most interesting and timely. Our laissez-faire plan, as physicians, in leaving this subject of illumination of our offices and appliances, for the major part, as an untrodden field of science, does not reflect credit upon ourselves.

I admit that physicians unassisted will not be able to take up the study, development and application of illumination at the very pit mouth of its existence. However, we must look, and we will look, to the Illuminating Engineering Society for most cordial co-operation and assistance in this subject. I may add, we are keenly desirous to learn of a lighting system which is founded on sound basic principles. Illuminating engineering, as a vigorous offshoot of electrical engineering, for the short space of its existence has made phenomenal progress. I am fully aware that no system of lighting could be looked upon as fixed in the present day trend of illuminating engineering. Of necessity, it is in a state of flux. It is in a fluctuating state with gainful developments from hour to hour.

However, a course of action is open to us. First and foremost, we will look to the members of our Illuminating Engineering Society, which is doing unique work, masterly and epoch-making in its character to help solve these problems for us. Thus will it not be possible for the Illuminating Engineering Society, working in conjunction with ophthalmological societies and many underlying and correlated societies to establish a uniform national basis for the standardization of electrical illumination in our work?

ACTIVITIES OF THE COMMITTEE TO COOPERATE WITH FIXTURE MANUFACTURERS*

An Outline of the Code of Fixture Design

BY SAMUEL G. HIBBEN

In the absence of this Committee's Chairman I have been asked to summarize the activities of this group of this Society's members, who, meeting with representatives of the National Council of Lighting Fixture Manufacturers, are endeavoring to simplify and standardize certain lighting devices. Our objects are to eliminate or modify such manufacturing practices as result in:

(A) Lighting Units that are menacing to safety, through electrical leakage, fire or explosive hazards, or danger of falling.

(B) Lighting Units that do not serve the purpose of good lighting, *i. e.*, those with unnecessarily bright, exposed light giving parts, or with mal-formed glassware or reflectors, or with similar optical or engineering shortcomings.

(C) Lighting Units having no unification of such essential dimensions as reflector shade-holders, or of globe fitters.

(D) Glassware (or metal) fitter-lips, and fitter heels, of a senseless variety of shapes and dimensions.

(E) Glass diffusing globes too small for the flux of light released within them; or the careless choice of lamps for the globes and reflectors.

(F) Mistakes of ventilation.

(G) Mistakes of accessibility for cleaning.

(H) Useless expense for duplication and small quantity reproductions of the essential parts of lighting accessories, which, non-interchangeable and slightly modified by each manufacturer, are only distinctions without differences.

(I) Pluralities of differing screw threads, tapped and threaded fits, etc.

*A progress report presented at the Annual Convention of the Illuminating Engineering Society, Rochester, N. Y., September 26–29, 1921.

It is proposed to evolve a Lighting Fixture Code, at first, at least, not mandatory but rather as a guide to manufacturers, and to include among a number of items the following:

(a) A list of the present nominal reflector fitter sizes (these of the prominent manufacturers of lighting glassware and metal accessories.)

Some of these sizes may be dropped from the standard list. Imported articles are to be considered here.

(b) The range of dimensions of fitters, heels, and openings.

1. Outside diameter; inside diameter.
2. Vertical dimension of heel and lip.
3. Shoulder diameter, and depth.
4. Depth of groove; distance from plane of deepest depth to top of lip.

These for blown, pressed and press-blown glassware and spun and cast metal articles.

(c) List of lamp bulbs passing through globe fitters clearances, tolerances, thickness of glass, and bulb variations.

(d) List of lamps usable within globes of varying depths. This applies to squat globes, and may include shallow dishes.

(e) Weights allowable on three set-screws, or similar points of support.

The places and conditions where wire netting about the glassware is needed, etc.

(f) Ventilation—assembly of such authentic data as now available, and if possible, further tests to enable the elimination of needless expense for glass drilling, metal punching, etc.

(g) Standardization of the depths of luminaire reflector husks. Limiting these to two depths.

(h) Standardization, or at least unification, of depths of detachable holders, such as Form "O," "H," "A" and many of their varieties.

(i) Minimum guages of metal for parts of luminaires that support glass reflectors, etc.

(j) The classification of diffusing glasses as to
  (1) Light density
  (2) Medium density
  (3) Heavy density

(k) The segregation of the illuminating glassware into five or six general groups, to be known by some such descriptive titles as "crystal," "opalescent," "homogeneous diffusing," "flocculent," "cased," etc.

(l) The classification of glassware according to its properties of diffusion (applying particularly to uncolored commercial globes and bowls.)

This may be extended to include maximum allowable wattage in globes of various areas, *i. e.*, the limiting intrinsic brightness.

(m) Classification of reflecting glassware, as to values of
  (1) Specular reflection
  (2) Semi-gloss reflection.
  (3) Diffuse (matt-surface) reflection

This may be extended to include silks, papers, and parchments.

(n) The recommended practices in the manufacture and use of combination gas-electric luminaires.

(o) The issue of a card of instructions regarding cleaning, attached to each lighting device retailed.

(p) The recommendations for non-abrasive portable extension lamp or flexible cord.

It will be seen that activities of this Committee more or less overlap certain ones of the Glass Guild and National Council's Standardization Committees, the N. E. L. A. Committee on Wiring, and perhaps the activities of the underwriters. Nevertheless if one publication or code could contain in ready reference form a quantity of pertinent data and recommendations, such would be helpful to both makers and users of lighting devices.

The work of this Committee involves considerable original research; as to the resultant code it is conceivable that such a Rome cannot be built in a day. One may at first thought be impressed with the large proportion of the work delegated to mechanical features of luminaires, but after all, good lighting

practice begins just there. Individuality of each manufacturer need in no sense be submerged by a unification of utilitarian parts of lighting devices.

So it is hoped that out of the work of this Committee there will eventually result a "fixture guide," if it be not termed a code, which will reflect the large amount of effort and work and co-operation between the Illuminating Engineering Society and the Lighting Fixture Manufacturers.

DISCUSSION

C. H. HOFRICHTER: The fixture manufacturers realize that we have learned a great deal already from what the illuminating engineers have told us. In fact, we know we have already accomplished something during the past year. I think the basis for our operations is for us to find a definite objective for which we wish to strive; the fixture manufacturers are greatly at sea.

I have studied the fixture industry for the last two or three years, it seems to me that we are more or less like the overgrown boy. The fixture industry has inherited a great many things from its past, we have always thought and operated in terms of gas, it has given us our livelihood. In the past few years we have had to reconstruct our industry, from an industry of gas to one of electricity. You can readily appreciate the difficulties we meet, when all our mechanics, designers, engineers, executives, are thinking in terms of work a little foreign to the modern thought of to-day in illuminants. So we covet and appreciate and invite the suggestions and cooperation of the engineers in helping the fixture manufacturers find a way out of their dilemma. I would like to make a suggestion to the engineers. The fixture manufacturers have been criticized very largely for making a cheap grade of fixtures. The reason they have made a cheap grade of fixtures has been because the demand of the market has been for that class of material.

I wonder if you realize as engineers that the majority of people in this country are poor people. You have taken away from the poor people the sixteen to twenty sources of light and have given them a bulb that costs twice as much, and every added thing that you have put into illumination has increased the cost of illumination to the ordinary individual or ordinary family.

We must talk of light as a necessity and not as luxury. A great many people do not live in terms of luxury, and I believe the engineers of to-day have a great field in helping the fixture manufacturer develop a unit that will fill the need of the average home, the workingmen's home, and not to supplement the work you have done, to fill the millionaires' homes and the homes of the high-salaried men. I believe you can contribute much to the science of illumination by helping us develop such a unit. That is the great cry which the fixture manufacturer hears and the reason that cheap material has been put on the market has been the fact that the merchant demands a unit that can sell at a price, and a fixture that can sell at a price, and this price has been called cheap.

Along with our education, we must develop from one step to another. I think it is rather impossible for us to hope to get the average individual on the high plane in which some of us live and I think that this is one of the great difficulties of the fixture industry. It is one of the places where we do not talk the same language, where we do not think in like terms, and where you will have to come down to us and we will have to try to get up to you at the same time.

C. F. Scott: I find a rather peculiar situation. As an Illuminating Engineering Society we can consider the laws of light and illumination, the eye, the artistic and so on. We have a special field of residence illumination, quite a study in itself from many aspects.

Several years ago a friend of mine was putting up a house, one of these simple, plain, ordinary citizen's houses. It cost about three thousand dollars. I was asked something about the illumination. I immediately thought in terms of this Society. I thought a particular study ought to be made of each room. It might be a matter of several days' study to work it all out. It would take a real illuminating engineer. It then occurred to me how much the service of an illuminating engineer would be worth, and how large an amount it would add to the cost of the house.

I was told that an estimate had been made for the fixtures and the complete list amounted to thirty dollars for the whole house. The men that sold fixtures had put in two bids, one thirty and the other thirty-five dollars, the fixture men had made the recom-

mendations, and I looked them over and looked wise, and said I thought either bid was pretty good.

A short time ago, I had the choice of fixtures for my own house. It was an old house in which gas had been used, and had just been wired for electricity. I thought I ought to have about the right thing so I studied the problem and thought about it a good deal from the standpoint of different rooms, and tried to apply the different formula and criteria of proper residence practice from what I had learned from this Society. I discussed the matter with the wiring firm, and they had a fixture man who brought a lot of his catalogues around, and we went through the house. Pretty soon I asked him what he usually put in a room of this kind. He said, "Well, we usually do so and so." In the parlor, hall, dining room, kitchen, bedroom, and so on, there were twenty kinds of problems, in the twenty-five outlets in the house.

The outcome was that I modified a few things, but about three-quarters or nine-tenths of it was on the advice of the fixture man of the wiring contractor, and the advice was pretty good.

Now, we heard from the fixture man himself a few minutes ago that they do not know anything about it, that their psychology is all wrong, that we have not gotten over the gas age yet. That presents a situation, if a great part of the residence lighting is done by the man who sells the fixtures, if the man that makes the fixtures is still in the gas age and does not know just what to do. If our Committee, as intimated, rather thinks it is a little too highbrow, we have a rather difficult problem. How are the criteria of good illumination to be applied to the varying conditions, I will say, of residence lighting, where the costs must be low, where the cost must be fixed by the fixture seller, unless we get very close to the fixture maker and get something which is sound and universal and cheap?

G. H. Stickney: Owing to the turn which the discussion has taken, I would like to add a few words.

There is always a tendency to pay too much attention to first cost, and not enough to the continuous operating cost and to the value of an advantage that operates continuously. The case of the carbon vs. the tungsten filament lamps has somewhat of a parallel to that of the cheap fixture vs. the superior, but more

expensive fixture. Of course, it is essential that the more expensive fixture (luminaire) be superior—which unfortunately has not always been the case. Some of the worst fixtures, from the lighting service standpoint that I have ever seen, are magnificent pieces of metal workers art in millionaires' residences. On the other hand, I hope that our friends in the fixture industry will join with us and advocate that which has superior merit from the users' standpoint, even though it be somewhat more expensive.

It seems to me that the illuminating engineer has considerable responsibility in bringing his views to the attention of the various branches of the lighting industry, remembering, of course, that proper weight should be given to artistic considerations, and that economy is not the whole problem.

S. G. Hibben: I would have liked to have heard from more of the lighting fixture representatives, but I think we have had a good discussion. I would like to have anybody else with other additional ideas come to me afterwards. Perhaps the Committee will be guided in its work along two different lines. We will try to work mechanical improvement in the design of the purely commercial types of fixtures which are sold in quantities; and on the other hand, give some time to the period styles of the higher groups of residence fixtures. I have in mind the truth that properly applied style and art does not mean sacrifice of engineering efficiency, and the "efficiency" in home lighting is a "gratification of the senses." We can afford to waste quantities of light in order to secure those things. We will try to remember that the Committee is as much interested in art and period styles as in commercial lines. We can do good work in both those fields.

Mr. Hofrichter commented on taking the word "luxury" out of the lighting fixture business. Another statement can be made that "illumination" is not a luxury any longer, but a necessary convenience.

SOCIETY AFFAIRS

SECTION ACTIVITIES

CHICAGO

Meeting—December, 1921.

At the meeting of the Chicago Section held at the Western Society of Engineers' Rooms on the evening of December 2nd, Mr. M. Luckiesh, Director of the Laboratory of Applied Science, Nela Park, presented an interesting paper on the subject "Lighting by Portable Lamps and Equipment." After the reading of the paper an interesting discussion followed. About thirty members and guests attended the meeting.

NEW YORK

Meeting—January, 1922.

A very interesting evening was devoted by the New York Section to the gas industry on January 12, 1922.

At the auditorium of the Consolidated Gas Company two papers were read. Mr. Sverre Gulbrandsen of the Welsbach Company presented the subject "The Origin of Modern Gas Lighting" and gave some interesting demonstrations during his talk.

The second paper of the evening, "Some New Wrinkles in Gas Lighting," was given by Mr. R. H. Maurer, who displayed a fine exhibit of a variety of gas fixtures and new ideas in globes made of quartz which were demonstrated during the evening.

The number of members and guests attending was approximately a total of 120.

PHILADELPHIA

Meeting—January, 1922.

The meeting of the Philadelphia Section on January 10, 1922, was designated as Ladies' Night, and was very successful.

Mr. W. V. D. Kelley of the Prisma Company, Jersey City, spoke on "Making Color Motion Picture Films." He described their company's two color film with its double emulsion and the two pictures super-imposed, one on each side. He projected each color separately on the screen and then showed how the two combined gave the desired true color. He illustrated both the earlier makes and the later types of film by passing them through the machine. His pictures of colored foliage and various fruits were most interesting and instructive.

After this Mr. Carrol H. Dunning of the same company discussed "The Psychology of Color in Photoplay Construction." He spoke of the added effect and interest of color applied to objects, particularly to persons acting in the present-day plays. His talk was illustrated by two incomplete parts of a photoplay based in London in the seventeenth century. A full size block of houses, the construction of which was based on old prints, was erected and actually burned to represent the Great London Fire. The mobs of people, the animals, and the burning houses; all their natural colors, were most realistic.

Thirty ladies and men participated at the dinner at the Arcadia Grill preceding the meeting, while the attendance at the meeting was approximately 115.

Afterwards a social time with light refreshments was provided by the Dinner Committee.

COUNCIL NOTES

ITEMS OF INTEREST.

At the meeting of the Council on January 12, 1922, the following were elected to membership:

Ten Associate Members

JOHN BEISWANGER,
Vice-President,
Gill Brothers Company,
7th and Franklin Streets,
Steubenville, Ohio.

LOUIS D. CARROLL,
Carroll Electric Company,
714 12th Street, N. W.,
Washington, D. C.

HARVEY DESCHERE,
Electrical Contractor,
405 Lexington Avenue,
New York, N. Y.

G. P. FUERST,
Harrington Electric Company,
413 Caxton Building,
Cleveland, Ohio.

LEWIS FUSSELL,
Prof. of Electrical Engineering,
Swarthmore College,
Swarthmore, Pa.

EDGAR A. HARTY,
Electrical Engineer,
204 S. Oxford Street,
Brooklyn, New York.

C. J. NETTING,
The C. J. Netting Company,
1502 Randolph Street,
Detroit, Michigan.

FREDERICK C. SASSE,
Sales Engineer,
X-Ray Reflector Company of New York,
31 West 46th Street,
New York, N. Y.

UHL M. SMITH,
Associate Physicist,
Bureau of Standards,
Washington, D. C.

ARCH K. WOOD,
General Superintendent,
McKee Glass Company,
Jeannette, Pa.

One Sustaining Member

KRICH LIGHT AND ELECTRIC COMPANY,
306 Market Street,
Newark, New Jersey.

CONFIRMATION OF APPOINTMENTS.

The appointments of the following chairman and committee members were confirmed:

As Member of the Committee on Research

Dr. Alexander Duane

As Members of the Committee on Membership

C. A. Atherton
George G. Cousins
Terrell Croft
E. Y. Davidson, Jr.
W. G. Gordon
J. J. Kirk
Clare N. Stannard

As Member of the Committee to Co-operate with Fixture Manufacturers

W. F. Minor

As Members of the Committee on Nomenclature and Standards

W. J. Drisko
Howard Lyon
G. A. Hoadley
G. H. Stickney

General Convention Committee

Charles L. Edgar, Chairman
H. F. Wallace, Vice-Chairman
Julius Daniels, Secretary

Committee on Advertising

H. Freeman Barnes, Chairman

COMMITTEE REPORTS

Committee on Membership.—Mr. G. B. Regar, Chairman, reported gratifying progress in the work of this committee. The country has been divided into districts, each of which has a regional director. A letter has been prepared which will be sent to every member of the Society, asking that recommendations for new members be sent in to the Chairman. A letter was read from Mr. S. G. Hibben in which he said that the Westinghouse Lamp Company is willing to insert in their next bulletin, a circular setting forth the advantages of becoming a member of the Illuminating Engineering Society, provided that the expense of printing the circulars would be taken care of by the Society. The Council authorized the printing of 10,000 of these circulars to be sent out as suggested by Mr. Hibben.

Committee on Editing and Publication.—Mr. Norman D. Macdonald, Chairman, told of the plans of the Committee for changing the number of issues of the Transactions to ten. The Volume will begin in January and be published monthly, with the exception of June, July and August. During the summer months there will be one issue, to be published about the 15th of July. A number of changes in the make-up of the Transactions are to be made which it is thought will improve the appearance of the publication.

The Council moved to accept the recommendations of the Committee on Editing and Publication in regard to changing the style of the Transactions and the dates of publications.

Committee on Nomenclature and Standards.—A communication from the Committee on Nomenclature and Standards was read, in which it was recommended that the Council of the Society submit to the American Engineering Standards Committee for approval as "American Standard" the present Nomenclature and Standards Rules of the Society—1918 edition;

The Council moved that this be done.

The Committee on Nomenclature and Standards also recommended that the Council request the American Standards Committee to designate the Illuminating Engineering Society sponsor for Illuminating Engineering Nomenclature and Standards for the purpose of organizing a Sectional Committee to take care of revisions shortly to be made in the existing Nomenclature and Standards Rules of the Society.

The Council moved to accept this recommendation also.

Revised Rules and Specifications for Test as Shown in Copy Submitted by the Committee on Motor Vehicle Lighting.—A letter was read from Dr. C. H. Sharp, Chairman of this committee, requesting the Council's approval

of the revised rules and specifications for test. The Council moved that this revision be approved subject to the approval of the Committee on Papers.

COMMITTEE ON TIME AND PLACE OF 1922 CONVENTION.—Mr. Walton Forstall, Chairman, recommended Boston, Mass. as the place for holding the 1922 Convention. The time suggested was the last week of September, but it was recommended that the exact date be left to the Chairman of the Convention Committee. The Council approved this report and moved that the Committee be discharged with thanks.

REPORT OF LETTER BALLOT ON REVISION OF BY-LAW FOR ARTICLE VII, SECTION 12 (r).—The General Secretary reported that the letter ballot had resulted in a concurring vote of a majority of the entire Council and that, therefore, according to the Constitution, the new By-Law is now effective, which reads as follows: "The TRANSACTIONS shall be issued at intervals to be determined by the Council."

NEWS ITEMS

DEAN COOLEY'S SOUTHERN TRIP

Dean M. E. Cooley, President of the Federated American Engineering Societies will make a trip through the southwest during February and March, in the interest of the engineering profession. He will speak before various engineering societies and engineering students in the colleges and universities. The itinerary includes principle cities in Kansas, Oklahoma, Texas, Louisiana, Alabama, Georgia, Tennessee and Kentucky. It is hoped that members of the Illuminating Engineering Society will co-operate in their respective localities to make this trip a success.

1922 CONVENTION AT BOSTON

Boston and the New England Section will entertain the Sixteenth Annual Convention of the Illuminating Engineering Society in September, 1922. The Council has appointed the Chairman, Vice-Chairman and Secretary of the 1922 Convention Committee. Plans are now being formulated and full publicity will be given to the members of the Society, and present indications point to a very successful convention.

The first annual convention of the Illuminating Engineering Society was held in Boston, July 30-31, 1907, during the administration of Dr. Clayton H. Sharp, the second president of the Society.

GENERAL OFFICE NOTES

Reprints of the "Code of Lighting, Factories, Mills and other Work Places" as published in the November 20th issue can be obtained from the General Office. There has been incorporated in the pamphlet a table of contents and an index. Price 25 cents per copy.

Discounts will be allowed for orders greater than fifty copies upon application.

Copies of the following issues are desired:

Vol. XV, No. 7, Oct. 10, 1920.

Vol. XVI, No. 3, April 30, 1921.

The General Office will pay fifty cents each for copies in good condition of these issues.

PERSONALS

Mr. William A. Durgin, of the Commonwealth Edison Company of Chicago, has become associated temporarily with the Department of Commerce, functioning under Secretary Hoover's direction in connection with a program of simplification-standardization in industry. It is understood that the key-note of this program is the application of the influence of the Department of Commerce in promoting co-operation of producers, distributers and users in a given industry with a view to elimination of needless sizes, styles, types, etc., in the interests of economy and interchangeability.

Mr. E. F. Newkirk, Department of Publicity of the Edison Lamp Works, has designed the layout of the new cover and the subject heads for the various departments of the TRANSACTIONS. The Committee on Editing and Publication now express its appreciation of the splendid co-operation of Mr. Newkirk.

Mr. F. M. Feiker, Vice-President of the McGraw-Hill Publishing Company, who for the past eight months has been assisting Secretary of Commerce Herbert Hoover in the reorganization of the Department has resigned. Mr. Feiker has not, however, completely severed his relations with the Secretary or the Department. He has been appointed a special agent of the Bureau of Foreign and Domestic Commerce, to continue in a consulting capacity the work he has been rendering.

Last May, Mr. Feiker was given leave of absence from the McGraw-Hill Company to join the Department of Commerce as a special Administrative Assistant of Secretary Hoover. He was selected because of his very wide knowledge of and experience and acquaintance in the American industrial field.

Under the direction of Mr. Feiker and Dr. Julius Klein, Director of the Bureau of Foreign and Domestic Commerce, the industrial and business contacts of that Bureau have been enlarged, business relations with trade association committees have been established and the so-called Commodity Divisions of the Bureau created. Mr. Feiker has drawn some fifty or sixty experts from the business world to the Department of Commerce to be of direct and specific service to American business. During Mr. Feiker's stay with the Department, *Commerce Reports* the Government's official foreign trade paper has been changed from a daily to a weekly publication and its style and appearance completely altered to more nearly meet the needs of business. The *Survey of Current Business*, a new publication destined to be of much assistance to American business men was brought into existence. Mr. Feiker's services extended to the Bureau of Standards, the Bureau of the Census and other parts of the Department. He served as Editorial Advisor on the Department's Board of Editors.

Mr. M. Luckiesh, of Nela Park, Cleveland, has brought out a new book, "Visual Illusions, Their Causes, Characteristics and Applications," which has been published by D. Van Nostrand Co., New York City.

OBITUARY

William H. Bradley, Chief Engineer of the Consolidated Gas Company, died suddenly of heart failure, January 18, 1922, in his office, in the Gas Company's building, No. 130 East 15th Street, New York. He had been Chief Engineer of the company thirty-six years.

William H. Bradley was born in New Haven, Conn., on August 25, 1838, he was the son of Charles and Sarah Stanley Bradley. He received a common school education and while still a resident of New Haven he married Elizabeth Whitlock, in 1859, who survives him. Shortly after his marriage he entered the service of the Continental Iron Works, Brooklyn, N. Y., as construction engineer. At that time that company was actively engaged in the execution of large governmental contracts, among them, in 1862, they were building Ericsson's Monitor, and Mr. Bradley took an active part in the building of that warcraft, which subsequently met and defeated the Merrimac.

Mr. Bradley lived a very active life and had been the chief moving spirit in many very large construction engineering propositions. Although eighty-four years old, he was a daily visitor to his office, where he took delight in studying plans and watching the daily details of the manufacture of gas, and its distribution. Early in January, Mr. Bradley accompanied by several officers of the Consolidated Gas Company, visited the works of the Astoria Light, Heat and Power Co., at Astoria, Long Island, where he turned the large bar that started the flow of gas into the newly completed 15,000,000 cubic feet gas holder. This was the second holder of that capacity that Mr. Bradley had seen completed on plans and specifications prepared by himself. In the late seventies, Mr. Bradley became convinced that the illuminating power of coal gas could be greatly increased by the infusion of naptha or gasoline, as a result, he performed considerable experimental work on coal gas and carburetted water gas.

Mr. Bradley on entering the employ of the Consolidated Gas Company, of New York, as Chief Engineer, in 1886, made an extended trip in Europe, where he studied the gas plants in various countries, and on his return made an extended report on all the properties of the Consolidated Gas Company and policies for future guidance to meet the phenomenal growth of New York City. His survey of the city led him to report that the time would come when the manufacture of all the gas necessary for the city would have to be made in some other place than on Manhattan Island. Two or three properties were called to his attention, and he selected the present site of nearly 400 acres at Astoria, Long Island, where the Astoria plant, the largest in the world, is now in operation. That plant, which has a daily capacity of 86,000,000 cubic feet of gas, was constructed under the plans and specifications in every detail as Mr. Bradley had planned. The equipment of the retort houses, the scrubbers, the tar extract houses and coal handling apparatus, as they are to-day, were all designed by Mr. Bradley.

PROFESSIONAL OPPORTUNITIES

Illuminating Engineer: A position is available with a corporation for an experienced engineer in the design and layout of factory lighting and general illumination work. G. L. S. (1)

ILLUMINATION INDEX

PREPARED BY THE COMMITTEE ON PROGRESS.

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TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

VOL. XVII FEBRUARY, 1922 NO. 2

The Idea Behind The Code of Lighting

WHILE THE CODE of Lighting Factories, Mills and other Work Places is intended as an aid to industrial commissions and similar bodies which actively take up questions of legislation as related to factory and mill lighting, it is intended in equal measure for the industries themselves. A statement to this effect is contained in the introduction to the revised I. E. S. code which was approved as an American Standard in 1921 by the American Engineering Standards Committee.

From the standpoint of the state labor department, the underlying idea of the code is to establish standards of illumination the enforcement of which will tend to safeguard the factory workers from accident and from undue eye strain. From a legislative standpoint the state is concerned chiefly with *protection* and only indirectly with *production*; hence the code rules, which are intended as a basis for state legislation, specify minimum requirements for safe and hygienic lighting. These requirements are not to be interpreted as sufficient to insure good lighting.

The industries on the other hand are concerned directly with production; to meet the requirements of the industries, the code sets forth standards not only for safe lighting but for productive lighting.

From the standpoint of the Society, the underlying idea of the code is not only to conserve the eyesight of the workmen and to make the factory a safe place to work in, but to prescribe the kind of lighting that will enable the workmen to do the best work. In carrying out this purpose the rules of the code have been intentionally subordinated to the section containing explanatory matter, suggestions and general information, which really constitutes the

body of the code; this section contains a table of approximate foot-candles in good lighting practice, a classification of light sources from the standpoint of glare and much other information and data of direct interest and value not only to the industries themselves but to the state labor department or other regulatory body that seeks to apply the code in practice.

Back of the few short rules of the code stands out the aim of the society to give a groundwork both educational and inspirational. It is gratifying to find that every state that has adopted the code has printed and disseminated not only the code rules with which the state is directly concerned, but also the full discussion of the principles of good lighting set forth in the code.

Experience in the operation of the code in the several states in which it has been in effect for some years shows that the operation of the code makes for the elimination of unnecessary waste and unnecessary fatigue in the industries, thus benefiting not only the workmen but the industries themselves and therefore the general public. With comparatively few exceptions there is an earnest desire on the part of factory owners and operators to comply with the provisions of the code. The only complaints that compliance with the rules would work an unnecessary hardship or unreasonable expense have come from those who wilfully provide unsafe and unhygienic lighting. It happens quite often that through ignorance of the requirements the factory management transgresses the law; but in such cases it is significant that once the attention of the owners is directed by the state inspection department, to violations of the rules, there is invariably prompt co-operation of the management in bringing the lighting up to standard,—not only up to the minimum permissible standards specified in the rules, but up to the standards of good lighting practice.

This experience proves that the idea behind the code has been realized in practice to a sufficient extent to justify the adoption of the code in every industrial state in the Union.

L. B. MARKS.

REFLECTIONS

Better Illumination as Aid to Defective Vision

THE REPORT of the Committee on Elimination of Waste in Industry of the American Engineering Council on "Accidents Due to Eye Defects" contains some very interesting observations regarding the prevalence of defective vision as found in the industries to-day. It stresses the importance of correcting subnormal vision among employees, insisting that excess eye fatigue results in conditions which must produce loss, due to lowering the quantity and quality of whatever is produced. Subnormal vision was found to be of great frequency. One investigation showed that out of 2,906 garment workers only 743 or a little over 25 per cent had normal vision in both eyes, 17 per cent having normal vision in one eye with the other eye defective. The highest percentage of defective vision was in the class of workers who made the greatest use of their eyes.

An examination of more than 10,000 employees in factories and commercial houses found 53 per cent with uncorrected faulty vision. Of 675 employees in a typewriter company, 58 per cent were found to be in need of correction by glasses. Of the rejections of the National Army, 21.7 per cent. were because of eye trouble. An examination of the vision of 3,000 employees in a paper box factory in Brooklyn, N. Y., showed that the percentage of normal was only 28. The report continues:

"As in the correcting of other factors of occupational hygiene, standards have been set; so, after further study, visual acuity standards will have to be determined for each grade of workers and readjustments made, with alterations in our methods of testing acuity to suit conditions, until these standards give us the necessary minimum for each kind of work. As examinations are made at present any set level would exclude workers shown by practice to be very efficient producers.

"Many subnormal eyes will work well even for fairly trying work if conditions are good. Therefore, it is first of all urgent to bring the working condition up to the best, on the basis now understood.

"Even the most superficial survey of lighting conditions reveals that in the majority of plants there is much improvement possible, in spite of the actual increase in production quantity and quality when poor illumination is corrected to standards now considered satisfactory. There seems to be no question of loss due to faulty lighting conditions."

One estimate, the report stated, placed the loss due to faulty lighting conditions in this country as above the entire cost of artificial illumination. In 446 industrial plants investigated only 8.7 per cent were found to be in excellent condition. The other ratings were: Good, 32 per cent; fair, 29.1 per cent; poor, 18.8 per cent; very poor, 3.5 per cent; partly good, partly poor, 7.8 per cent. *Journal of the A. I. E. E.*, Feb., 1922.

What is a "Luminaire"?

IN THE REPORT of the Committee on Nomenclature and Standards of the Illuminating Engineering Society presented at the annual convention at Rochester, the matter of a generic term for "lighting unit" was considered. The Committee recommends the use of the term "luminaire" as being most acceptable. This word possesses the advantage that it is not coined but is already in use in the French language in this connection. The Committee considers it equally appropriate and understandable in English.

The time seems propitious for some such standard as this. "Lighting unit" is at best rather clumsy and "fixture" scarcely descriptive. The Elexit will, no doubt, have a wide use, and the expression "removable fixtures" has often been applied in discussing the use of Elexit. Obviously, "fixture" indicates something stationary or fixed and it is rather ridiculous to speak of "removable fixtures." Similarly table lamps and floor lamps are portable and cannot be called fixtures. The term "luminaire" will cover all these cases. Let us get behind its use and secure the universal adoption of this term. *The Edison Sales Builder*, Jan., 1922.

Milwaukee Lighting Interests Organize

THE ELECTRICAL interests of Milwaukee have combined forces to promote better lighting in Milwaukee and throughout Wisconsin. The work is being carried on under the auspices of the Electrical Development Association of Wisconsin.

The Association has already established a bureau in the First Wisconsin National Bank Building, where all questions relating to the wiring of buildings and electrical illumination will be answered free of charge by experienced lighting experts. The Association does not take contracts nor sell fixtures, but part of its free service consists in furnishing approximate estimates.

The main purposes of the Association, however, are the dissemination of up-to-the-minute information on better lighting among those engaged in the electrical business, informing the public through every effective agency of the value of better lighting in the home, in the office, the store and the factory and finally backing up this publicity by means of actual demonstrations. The financial, physical, moral and artistic advantages of better lighting will be explained and emphasis will be placed on the fact that better lighting is easily within the financial reach of all who are able to enjoy even the moderate comforts and conveniences of life.

The publicity is in charge of a publicity committee, the members of which are F. A. Coffin, J. C. Schmidtbauer and Arthur Polacheck. Charles L. Benjamin, Chicago and Milwaukee, has been appointed director of publicity.

The officers of the Electrical Development Association of Wisconsin are as follows: President, R. M. Van Vleet; Vice-President, Phil Polacheck; Secretary, F. A. Coffin; Treasurer, P. C. Burrill; Directors, H. P. Andrae, R. M. Van Vleet, Phil Polacheck, F. A. Coffin, F. M. McInery, F. A. Vaughn and P. C. Burrill.

Industrial Lighting Demonstrations

THE INDUSTRIAL LIGHTING exhibits which were initiated last Spring by the Edison Lamp Works in eighteen states of the country are again being conducted. Two booths are on tour this year. The first started in New York State, continuing through Ohio from which it will go to Indiana, Michigan, Illinois and down along the Mississippi, across Tennessee and back to Harrison, N. J. The other booth started through New England, New Jersey and probably will tour several of the Southern States.

Demonstrations of various types of lighting units ranging all the way from unshaded, glaring lamps to the latest, best and most efficient units are given in a portable canvas booth. Thus, those who attend have an opportunity to judge for themselves the relative efficiency and desirability of the different types being aided by foot-candle meters which are distributed among the men. A miniature show window forms part of the exhibit during the demonstration, lighted with colored lights showing the effects that may be obtained in show window illumination not only by the use of primary colors but by combinations also.

Last winter and spring three booths accompanied by demonstrators were in use. Seventy-two cities were visited and the total attendance was approximately 10,800. Seventy-five per cent of those attending were industrial executives, such as presidents, secretaries, purchasing agents, superintendents of industrial concerns. Ten per cent were industrial men such as foremen and electricians, while another ten per cent consisted of representatives of civic organizations such as chambers of commerce, boards of trade, and Rotary and Kiwanis Clubs.

Color Lighting in Theatres

THE MAGIC of ever changing color harmonies is secured through a system of lighting from concealed sources with all lights operated through dimmers. The Pantheon Theatre, Chicago, has installed such a system of cove lighting; the cove is used to conceal the source of the color lighting so effectively employed to display the beauty of the interior decorations.

A series of powerful reflectors fitted with clear bulb electric lamps is built in the cove. Colored screens, red, blue and green are alternated over the reflectors to produce color lighting. Every fourth reflector in the series is without a color screen, this being used to give the clear white light.

It is important that all colored lighting circuits and desirable, at least, that the white light circuit be connected through a dimmer equipment. Only by the mixing of color as accomplished by dimmers—increasing one color, diminishing another, as an artist would mix his color pigments—can the utmost value be realized from this equipment.

Wasted Light

AT LEAST ONE-HALF, and sometimes practically all, of the light utilized in interiors is received by reflection from ceilings and walls. In our campaign of enlightenment we should not overlook the fact that a great deal of light is wasted in plants whose walls and ceilings are dirty and poorly painted. One paint manufacturer, speaking of plants operating part of the day under sunlight and the balance of the day under artificial light, states that using the right kind of paint on the walls and ceilings reduces production costs 16 to 21 per cent. *The Jobber's Salesman.*

PAPERS

THE EFFECT OF VARIATION OF VISUAL ANGLE, INTENSITY, AND COMPOSITION OF LIGHT ON IMPORTANT OCULAR FUNCTIONS. *

BY C. E. FERREE AND GERTRUDE RAND.**

INTRODUCTION.

In a study[1] reported to the Illuminating Engineering Society last year, the benefit of increase of illumination was shown for the following functions of importance to the working eye,—acuity, power to sustain acuity, speed of discrimination, and speed of adjustment for clear seeing at different distances. Moreover, the benefit of the increase was shown to be considerably greater for eyes suffering from a slight refraction defect than for the normal eye. It was promised in that paper that the effect on speed of discrimination would be investigated later for a wider range of visual angle. During the past year an investigation has been made for as wide a range of visual angle as the speed of our exposure apparatus would permit for the range of intensities employed; and a greater number of observers has been used. The investigation has been extended to include also the effect of variations in composition of light. This latter feature of the investigation has been undertaken anew at the request[2] of the American Writing Paper Co. of Holyoke, Mass., who in seeking for the specifications of the ideal printed page have wanted to know among other things the effect of color of the page or other working surface on the functional powers of the eye. In former studies the comparative tendencies of difference in composition and color of light to cause ocular fatigue and discomfort have been determined and the results reported to this Society. In this study the investigation has been extended to include the effect of these factors on acuity, power to sustain acuity, and speed of discrimination. As was stated in the former paper speed of discrimination and power to sustain acuity are all aspects of

* A paper presented at the Annual Convention of the Illuminating Engineering Society, Rochester, N. Y., September [illegible], 1921.

** Department of Psychology, Bryn Mawr College, Bryn Mawr, Pa.

[1] The Effect of Variations in Intensity of Illumination on Functions of Importance to the Working Eye, Trans. I. E. S., 1920, XV, pp. 769-792.

[2] This request came through Dr. R. E. Rindfusz, Director of Technical Research of the American Writing Paper Co.

acuity, but are aspects not taken account of in the conventional acuity tests. They are aspects, moreover, which are of very great importance to the working powers of the eye.

The more significant features of the results obtained may be summarized in the following statements:

(1) There is a gain in the speed of discrimination for all of the visual angles employed. This gain is very great from low to high illumination when the visual angle is small. As might be expected, the effect of increase of intensity of illumination on the speed of discrimination grows less as the visual angle increases. However at a value of 3.45 minutes of arc the effect is still great. With a value of 1.15 minutes of arc the increase in speed produced by changing the illumination from 0.4 to 12 foot-candles amounted to 603 per cent. With an angle of 2.49 minutes of arc,—a value roughly approximating the details in 10–point type at the conventional reading distance of 33 cm.—the increase was 331 per cent; and with a value of 3.45 minutes of arc the increase was 310 per cent.

(2) The effect of increase of visual angle is greater than the effect of increase of illumination. And just as the effect of increase of intensity of illumination on speed grows less as the visual angle is increased, so does the effect of increase of visual angle on speed grow less as the intensity of illumination is increased. That is, we get a greater benefit of increase of illumination when the work is small and a greater benefit of increase in the size of the work when the illumination is low.

(3) In the investigation of the effect of composition of light on acuity, speed of discrimination, and power to sustain acuity, two intensities of spectrum lights were used. Wave-lengths were selected at seven representative points in the spectrum,—in the red, orange (orange-red), yellow, yellow-green, green, blue-green, and blue; and all were made photometrically equal at the test-object. Of these the highest acuity was found for the yellow and the lowest for the blue. Ranked as to acuity from greatest to least the following order was obtained for the lower of the two intensities employed,—yellow, yellow-green, orange, green, red, blue-green and blue. The spectrum blue and blue-green could not be obtained at the higher intensity. At this intensity the ranking of the other five colors remained the same as for the

lower intensity. The effect of difference of wave-length on acuity was greater at the higher than at the lower of the two intensities. This was doubtless due to the relative saturations of the colors at the two intensities. That is, the difference in saturation between the colors was greater at the higher intensity.

At the higher intensity the acuity was determined also for the Macbeth daylight glass transmitting the light of the type C lamp operated at 108 volts; and for the light of this lamp unfiltered. The acuity in both cases was higher than for the yellow of the spectrum, and higher for the daylight glass than for the unfiltered light of the type C lamp. The comparison was not made at the lower intensity. The light transmitted by the daylight glass was a mixed light but it had a considerable advantage for ease of discrimination over the yellow with regard to both hue and saturation. That is, the test surface illuminated by it appeared as a clear white light on which the test character stood out with great clearness and distinctness. The uncorrected light of the type C lamp also suffered the disadvantage of being a mixed light but it had an advantage over the yellow in the saturation of the color component. Had the intensities been higher and the saturation of the yellow correspondingly reduced, the results of the comparison might have been very different. As it was, however, the advantage of the yellow in homogeneity as to wave-length was more than overcome by its disadvantage in hue and saturation. Hue and saturation are very important factors in acuity. For example, the amount of color introduced into the light of the type C lamp by operating it at 90 volts gave it a lower acuity than the yellow, approximately equal to the yellow-green, when the comparison was made at the lower of the two intensities.

(4) The ranking as to speed of discrimination was the same throughout as the ranking for acuity for all of the lights employed,—the spectrum lights, the daylight glass, and the type C lamp. In general, however, the effect of change of composition on the speed of discrimination is very much greater than on acuity. For example, the acuity for the spectrum yellow was for the lower of the two intensities of light employed 2.2 times the acuity for the blue; while the speed of discrimination for the yellow was 9.7 times that of the blue. The acuity was determined

with an exposure of 1 second. If the time of exposure had been longer than 1 second the difference between the results for the two tests would have been greater still.

(5) The ranking as to power to sustain acuity was also the same throughout as the ranking for acuity for all the lights employed with the exception of red and green. A higher acuity and speed of discrimination were obtained for green than for red; but in case of the power to sustain acuity the reverse was true. The eye sustains its acuity better under red light. With reference to power to sustain the most striking feature is the very great difference in effect for the different wave-lengths. As compared with the results of last year, power to sustain as a test shows a much greater sensitivity than acuity and speed for picking up differences in the effect of wave-length than for picking up differences in the effect of intensity.

The work on color is intended merely as a preliminary, not an analytical investigation. Any very serious attempt at explanation is, therefore, futile at this time, and factors can be indicated only in a very tenative way..

Acuity.—Considered with reference to the eye there are three factors in acuity or the power of the eye to see clearly,—the resolving power of the refracting media, the space discrimination of the retina, and its sensitivity to light. To put it another way, there are the resolving power of the refracting media or the power to form clear images on the retina and the resolving power of the retina or the power to discriminate detail in the physical image formed. There is little doubt that the explanation of the effect of the wave-length of light on acuity is to be found in terms of the resolving power of the retina, not of the refracting media. Rayleigh has claimed that lenses give sharper images for the short wave-lengths than for the long. While this may be a factor in the power of the eye to see clearly, it is obvious from the above statement of results that it can not be the determining factor.

Considered with reference to the stimulus light, six factors may be mentioned that are effective in acuity,— the physical factors: intensity, wave-length, and purity of light; and their three subjective aspects: hue, saturation, and brightness. Of these, wave-length and purity alone affect the resolving power of the refracting media or the power to form clear images. In-

tensity, hue, saturation and brightness affect the power to discriminate details in these images, or what we have called the resolving power of the retina. For example, the ease with which the details in a black test-object can be discriminated on a colored background varies both with the hue and saturation of the color. Moreover the factors hue and saturation are interacting. That is, the effect of hue varies with the saturation and conversely the effect of saturation varies with the hue. A part of the advantage of yellow over the other colors is doubtless in part due to its low saturation. One of the features of future investigations will be to determine the effect of differences in hue when the saturation and brightness are kept the same, and the effect of saturation when the hue and brightness are held constant.

One is tempted to add clearness as a fourth subjective aspect of color. The test surface illuminated by blue, blue-green or red seems somewhat as if it were viewed through a solution in which some of the pigment was not dissolved but held in suspension. However, this visual murkiness is perhaps a combination of the effect of hue and saturation, and not a separate factor. In white light vision at good intensities one might almost be led to think that he is dealing directly with the physical image, so clear and stable are the processes involved. In color vision the situation is different. So many phenomena occur to confuse clear seeing in color vision that one falls quite naturally into the use of such explanatory terms as the resolving power of the retina.

Speed of Discrimination.—The speed of discrimination should be affected by everything that affects acuity, and to a much greater degree than acuity is affected particularly if the time of exposure in making the acuity determination is long. In addition there is a lag in the retina's response to light and color which differs with the wave-length and intensity of light. The differential effect of this factor however is probably pretty well masked by the other factors which affect discrimination.[8]

[8] Observers having a slight manifest hyperopia showed a relatively greater lag of discrimination and a greater practice effect for the long wave lengths, particularly the red; and observers slightly myopic showed a similar effect for the extreme short wave lengths. The effect was also noticeable in the low hyperopic and myopic astigmatisms. The lag in the hyperopic meridian was relatively greater for the long wave-lengths; and the lag in the myopic meridian was relatively greater for the short wave-lengths. These are noted merely as interesting and suggestive observations. Before acceptance, they should be confirmed on a larger number of subjects.

Power to Sustain Acuity.—The power to sustain acuity also should be affected by everything that affects acuity. This is particularly true with regard to factors which affect the resolving power of the refracting media, for example, slight astigmatisms, etc. With regard to the resolving power of the retina, however, the correspondence does not seem to be so close. For example, colored lights giving a relatively high acuity may not give an equally relatively high power to sustain acuity. As a factor in the power of the retina to sustain its resolving power, the rate of decay of sensation for the different colors should be taken into account; also the phenomena which accompany decay when the retina is stimulated by colored light. For example, the streaming phenomenon[4] which interferes greatly with the power to sustain clear discrimination seems to take place more strongly for some wave-lengths than for others, more particularly for the short wave-lengths. Green, blue, and blue-green seem especially active in producing this phenomenon. It may be stated as a general principle that the retina shows greater instability in retaining its resolving power under colored light than under white light, and that this instability is greater for some colors than for others.

It is significant to note that the retina has not only developed its greatest power to give the achromatic response to the wave-lengths in the mid region of the spectrum, but over and above this, that is, when all are equalized in power to give the achromatic response, these wave-lengths still have a very great advantage for the three most important aspects of clear seeing,—acuity, speed of discrimination, and power to sustain acuity. Yellow stands at the head of the list in all the tests that have as yet been applied,—acuity, power to sustain acuity, speed of discrimination, and the tendency to produce ocular fatigue and discomfort. Yellow-green and green stand comparatively high in the first three tests, but have not ranked so well in the tests for fatigue and discomfort. Even the three-minute tests of power to sustain acuity give evidence of the inability of the retina to hold its resolving power under the action of these wave-lengths. The indications from this and the previous work are that the ruddy yellows up to and well into the orange rank comparatively high all around;

[4] C. E. Ferree, The Intermittence of Minimal Visual Sensations, *Amer. Jour. Psychol.*, 1908, XIX, pp. 59-129; The Streaming Phenomenon, *Ibid* pp. 484-503.

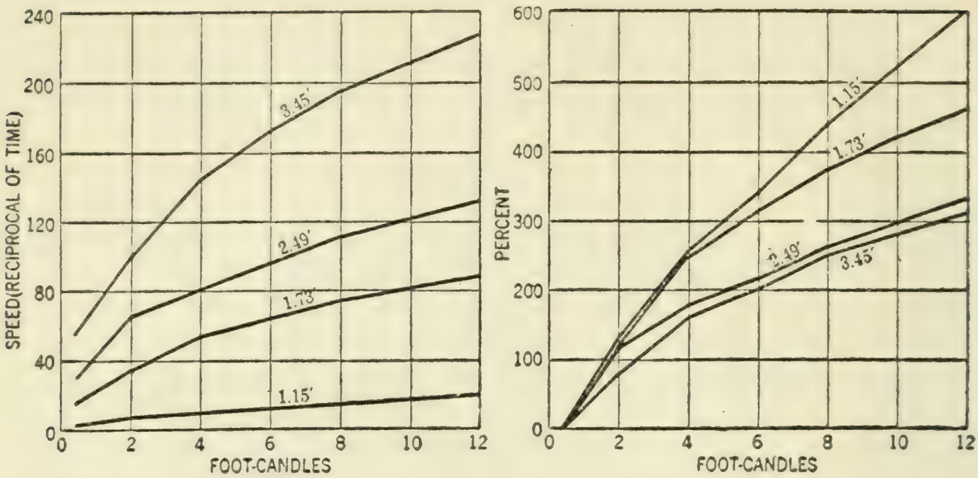
while the deep reds, the blue-greens, and the blues are obviously not meant to serve as backgrounds upon which achromatic details must be discriminated with precision, ease, and speed for long periods of time.

THE EFFECT OF INTENSITY OF LIGHT AND SIZE OF VISUAL ANGLE ON SPEED OF DISCRIMINATION.

This work was done on 13 observers. The test-object was a broken circle, the opening of which subtended visual angles respectively of 1.15, 1.73, 2.49 and 3.45 minutes of arc at the eye of the observer. The circle was mounted at the center of a graduated rotating dial. Exposures were made by means of a tachistoscope somewhat similar to that devised by us for the Air Service of the U. S. Army, furnished with only one set of exposure discs rotating in front of and as close as possible to, the test-object. On the front surface of these discs in line with the observer's eye and the test-object was placed a fixation cross in order that the exposure might begin with the eye in approximate adjustment for the test-object. The determinations were made at 0.4, 2.0, 4.0, 6.0, 8.0 and 12 ft-c. of light normal to the surface of the test-object. The reflection coefficient of the test surface was eighty-five per cent. The angle of incidence of light on the test surface was kept constant for all illuminations. The eye was allowed to adapt to each intensity of light through a 30-minute practice series provided with normal rest periods. In the final series eight positions of the test-object were used,—up, down, right, left and the four 45–degree positions.

The average results of the thirteen observers of normal refraction for 1.15, 1.73, 2.49 and 3.45 minutes of visual angle are plotted in Figs. 1 and 2[*]. The third of these values 2.49 minutes, is approximately the visual angle subtended by the details of 10-point type at the conventional reading distance 33 cm. Speed is expressed as the reciprocal of the time in seconds required to make the discrimination, that is, 1 divided by this time. In Fig. 1 speed is plotted against foot-candles. A strong effect of the increase of illumination is seen for all visual angles.

[*] For the larger part of the data represented in Figs. 1–4, we are indebted to Louise Sloan and Marion O'Brien, graduate students in the Bryn Mawr laboratory.



Figs. 1 and 2.—Showing the effect of increase of intensity of light on speed of discrimination (13 observers): Fig. 1, speed of discrimination plotted against foot-candles; Fig. 2, percentage gain in speed of discrimination plotted against foot-candles.

In Fig. 2 is shown in per cent the increase in speed produced by increasing the illumination for each of the visual angles. As might be expected the effect of increase of illumination becomes less as the visual angle or size of object is increased. There is good reason for believing, however, that there is a considerable effect even for very large visual angles.

In Fig. 3 speed is plotted against visual angle. In Fig. 4 is shown for comparison the effect on speed of discrimination both of increase of illumination and of increase of visual angle. Both sets of curves are plotted on the same per cent ordinate. The following points may be noted. (1) The effect of increase of visual angle is greater than the effect of increase of illumination. (2) Just as the effect of increase of illumination on speed becomes less as the visual angle is increased, so does the effect of increase of visual angle on speed become less as the intensity of illumination is increased. That is, we get a greater benefit of increase of illumination when the work is small, and a greater benefit of increase of the size of the work when the illumination is low.

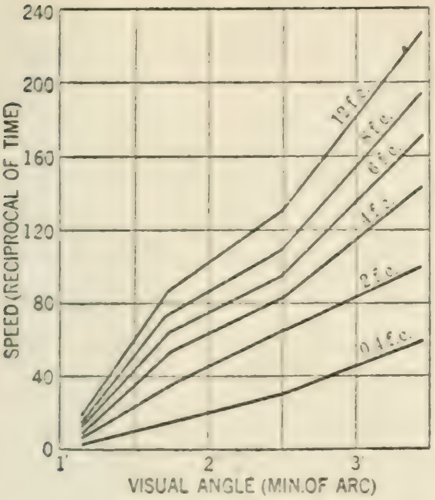


Fig. 3

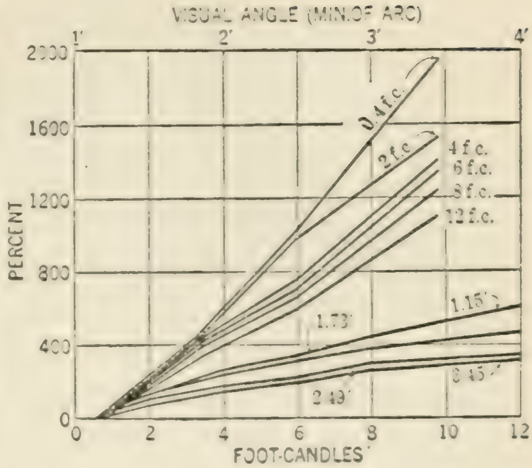


Fig. 4

Fig. 3— Showing the effect of increase of visual angle on speed of discrimination at 0.2, 2, 4, 6, 8, and 12 foot-candles of light normal to the surface of the test-object. Speed of discrimination is plotted against minutes of arc.

Fig. 4.—Showing a comparison of the effect of increase of intensity of light and of size of visual angle on speed of discrimination. Both sets of curves are plotted on the same per cent ordinate.

THE EFFECT OF VARIATION OF COMPOSITION OF LIGHT ON ACUITY, SPEED OF DISCRIMINATION AND POWER TO SUSTAIN ACUITY.

In taking up the problem of color of paper in relation to the eye we found that it was neither practical nor feasible to work with colored papers. The control of factors needed could not be secured without prohibitive trouble and expense with colored paper. Essentially the same purpose can be served by using white paper illuminated by colored light and a much better control of factors can be had.

However, it is obvious that even by the use of colored light a complete separation of factors can not be accomplished. The best that can be done is to vary together certain closely related factors and hold the remainder constant. For example, wave-length, hue and saturation can be varied together and purity and photometric intensity or brightness can be held constant; hue, wave-length or composition and purity can be varied together and saturation and brightness held constant; saturation, purity and composition can be varied and hue and brightness held constant; etc. Final conclusions as to the relative importance of factors can not be drawn from any one series of determinations. They will have to come from an intercomparison of the individual series.

For the work to be reported in this paper there has been chosen the first of these sets of variations. For its accomplishment spectrum lights are required. In using spectrum light for this purpose two possibilities are open; it can be used to illuminate a test-object seen by reflected light (the determinations made being then limited to low intensities); or it can be focussed on the eye in which case higher intensities are possible. The first of these alternatives has been chosen for the following reasons. (1) It would be difficult to make the three determinations,—acuity, speed of discrimination and power to sustain acuity—under comparable conditions with the light focussed on the eye. (2) Because of its superior sensitivity for picking up small differences in effect and its advantages for imposing an objective check on the correctness of the judgment we have wanted to use the broken circle as a test-object. No test-object nearly so good has as yet been devised suitable for use with light focussed on the eye. (3) We have wanted to express acuity in absolute or visual angle rather than in relative terms. This could not be done with any test-object known to us which could be used with the light focussed on the eye. (4) At one of the intensities used yellow gave an average acuity slightly greater than 1, $^6/_6$, or $^{20}/_{20}$ for all of the observers employed. Moreover any further increase in this intensity caused a decrease in saturation for some of the colors, for example, yellow, orange and red. That is, at the higher intensity more than half of the colors were either at or above their maximum saturation. At the lower intensity yellow was approximately at its maximum saturation,—the remainder of the colors below the maximum. It seemed allowable, perhaps advisable, therefore, to conduct one series of experiments at these intensities even though they were considerably lower than the intensities found in practical lighting situations.

The light was obtained from a spectroscope designed especially to give high intensities, with long collimator and objective slits and correspondingly large lenses and prism. The collimator slit was 12 mm. long. The collimator lens was a Zeiss triple achromat 180 mm. focal length, 600 mm. diameter. The prism was 100 mm. high, with a face 85 mm. in length. The source of light was a well seasoned Nernst filament mounted in exact alignment with the collimator slit and as close to it as

possible. The breadth of the objective slit was 0.5 mm. The light from the slit was spread directly to the test-object. The surface illuminated subtended a visual angle of 30.07 x 21.33 min. of arc at 6 meters. The variations of intensity were produced by varying the width of the collimator slit. The light reflected from the test surface was examined for purity with a small Hilger spectrometer furnished with an illuminated scale. No impurities above the threshold of sensation were found in any of the lights used after they had suffered reflection from the test surface.

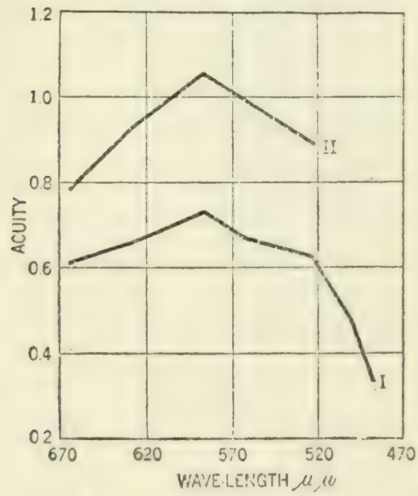
The lights selected were narrow bands in the red ($666\mu\mu$), orange ($624\mu\mu$), yellow ($587\mu\mu$), yellow-green ($563\mu\mu$), green ($522\mu\mu$), blue green ($501\mu\mu$) and blue ($488\mu\mu$). Two intensities of light were used 0.075 and 0.3116 ft-c. (0.81 and 3.35 meter-candles) designated respectively in the curves following as intensities I and II. The lower of these two intensities was the maximum obtainable for the blue in the spectrum employed. Neither the blue nor the blue-green could be obtained at the higher intensity. The lights were made photometrically equal at these intensities. The equalization was based on the average results of two observers practiced in making the judgments of heterochromatic photometry.

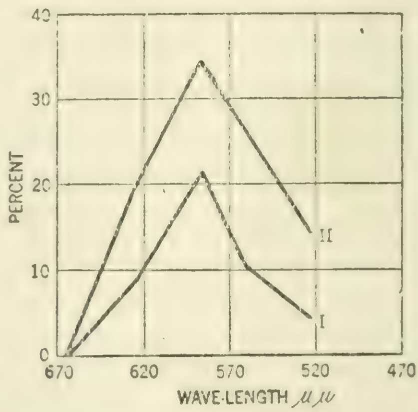
Acuity.—Three observers were used in making these determinations. The work was done in a dark room. The eyes were given a 30-minute adaption period before any observations were made. Also before the final determinations were made for each color a practice series of 15 minutes with proper rest periods was given. The broken circle (the international test-object) mounted on a rotating dial was used as test-object. In making the judgment all that was required of the observer was to indicate the direction in which the opening pointed. The judgment on which the estimate of acuity was based was thus reduced to very simple terms and an objective check was had on its correctness. In the final series of determinations this opening was turned in haphazard order right, left, up, down and the four 45-degree positions. The breadth of the opening was measured on a micrometer comparator and the visual angle computed. The coefficient of reflection of the test surface was 85 per cent. The pre-exposure and surrounding field were made in each case as

nearly as possible of the same brightness as the test surface. An exposure of 1 sec. was allowed for each judgment. The angle of incidence of light on the test surface was kept constant throughout the experiments. Constancy of position of the observer's eye was secured by biting a mouth board in which the impression of his teeth has previously been made and hardened in wax.

Curves showing the average results for the three observers are given in Figs. 5 and 6. In Fig. 5 acuity is expressed as the reciprocal of the visual angle discriminated, that is, 1 divided by the value of the visual angle. Acuity is plotted against wave-length. For the lower intensity the lowest acuity is found in the blue and the highest in the yellow. The ranking from highest to lowest is in the following order, yellow, yellow-green, orange, green, red, blue-green and blue. For the higher intensity the order from highest to lowest is yellow, yellow-green, orange, green and red. At the higher intensity the acuity in the yellow is 1.052. This is slightly greater than the Snellen norm for the emmetropic eye. The acuity for the yellow-green is approximately equal to the Snellen standard for the normal eye.

At the higher intensity the acuity was determined also for the Macbeth daylight glass transmitting the light of a type C lamp operated at 108 volts; and for the light of this lamp unfiltered. The acuity for the daylight glass was 1.125; for the tungsten lamp, 1.077; and for the yellow of the spectrum, 1.052.





Figs. 5 and 6.—Showing the effect of change of wave-length of light on acuity at 0.075 and 0.3116 foot-candle of light, intensities I and II, (3 observers). Fig. 5, acuity plotted against wave-length; Fig. 6, percentage change in acuity plotted against wave-length. The lowest value of acuity common to both curves in Fig. 5 is taken as the base on which to calculate the percentage change.

In Fig. 6 are curves showing the percentage change in acuity with change of wave-length for both intensities of light. In these curves percentage change of acuity is plotted against wave-length of light. In both cases the lowest value of acuity common to both curves in Fig. 5, is taken as the base on which to calculate the percentage change. This is the acuity for red. Blue and blue-green are not represented in the curve for the higher intensity. The percentage change from red to yellow for the lower intensity was 21.4; for the higher intensity 34.65. The percentage change from blue to yellow for the lower intensity was 120.41. The change from red to yellow, it will be noted, was greater for the higher intensity. This was doubtless due to the relative change in saturation of the two colors with the increase of intensity. That is, yellow was around its maximum saturation at the lower intensity and lost saturation as the intensity was increased. This relative change in saturation will doubtless be found to be a strong factor in the relative acuities of the colors at different intensities of light. To investigate this point an intensity curve should be determined for the different colors and the shape of these curves be compared with that of the saturation curves for the colors.

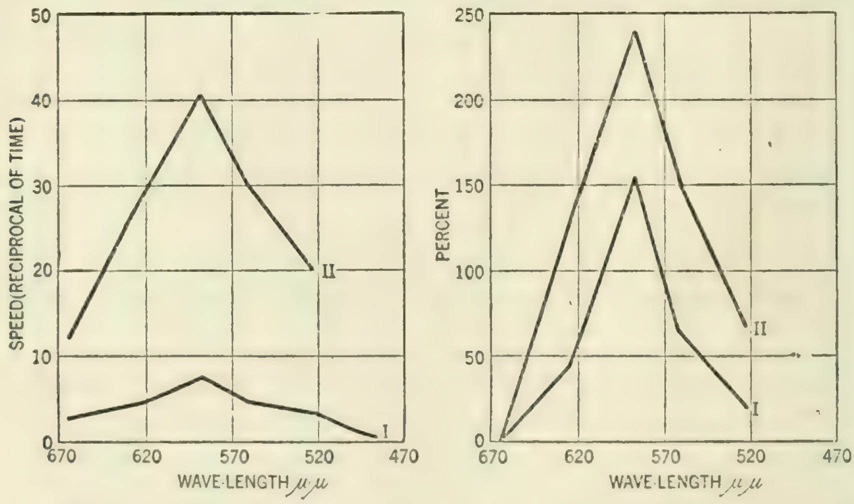
Speed of Discrimination.—These determinations were made for six observers. Again the test-object was a broken circle, the opening of which subtended a visual angle of 2.49 min. of arc at the observers eye. The circle was mounted at the center of a graduated rotating dial. The exposures were made by means of a tachistoscope furnished with only one set of exposure discs rotating in front and as close as possible to the test-object. On the front surface of these discs in line with the observer's eye and the test-object was placed a fixation cross in order that the exposure might be given with the eye in approximate adjustment for the test-object. The reflection coefficient the test surface was eighty-five per cent. The angle of incidence of light on the test surface was kept constant for all of the determinations. The work was done in a dark room. The eye was given a 30-minute adaption period before any observations were made. Before the final determinations were made a practice series of twenty

minutes, with proper rest periods, was given. In the final determinations eight positions of test-object were used,—up, down, right, left and the four 45-degree positions.

The average results for the six observers for both intensities of light are shown in Figs. 7 and 8. In Fig. 7 speed is plotted against wave-length. Speed is expressed as the reciprocal of the time in seconds required to make the determination. The effect of change of wave-length on speed is much greater than on acuity, but in general the type of effect is the same. The order of rating from highest to lowest is for the lower intensity yellow, yellow-green, orange, green, red, blue-green and blue; and for the higher intensity yellow, yellow-green, orange, green and red.

The speed of discrimination both for the Macbeth daylight glass transmitting the light from a type C lamp operated at 108 volts, and the unfiltered light from this lamp, was greater than for the spectrum yellow. The speed from the daylight glass was greater than for the unfiltered light of the type C lamp. The speed for the daylight glass was 58.46; for the tungsten lamp, 48.89; and for the yellow of the spectrum, 40.87.

In Fig. 8 are given curves showing the percentage change in speed with change of wave-length for both intensities of light. In these curves percentage change in speed is plotted against wave-length. In both cases the lowest value of speed which is



Figs. 7 and 8.—Showing the effect of change of wave-length of light on speed of discrimination, intensities I and II (6 observers). Fig. 7, speed of discrimination plotted against wave-length; Fig. 8, percentage change in speed of discrimination plotted against wave-length. The lowest value of speed common to both curves in Fig. 7 is taken as the base on which to calculate the percentage change.

common to both curves in Fig. 7, is taken as the base on which to calculate the percentage change. This is again the acuity for red. Blue and blue-green are not represented in the curve for the higher intensity. The percentage change from red to yellow for the lower intensity was 155.65; for the higher intensity, 239.99. The change from red to yellow, it will be noted, was greater for the higher intensity as was the case for acuity; and as might be expected, the difference in effect which was in all probability due to the difference in the relative saturations of the colors, was greater for speed than for acuity. The percentage change from blue to yellow for the lower intensity was 867.76.

In Fig. 9 are given curves showing the individual results for the six observers. The general similarity as to type of results is obvious from these curves. The chief difference is in the order of magnitude of speed.

Power to Sustain Acuity.—For these determinations a value of visual angle was selected slightly greater than the minimum visual angle for the color giving the lowest acuity, namely, the

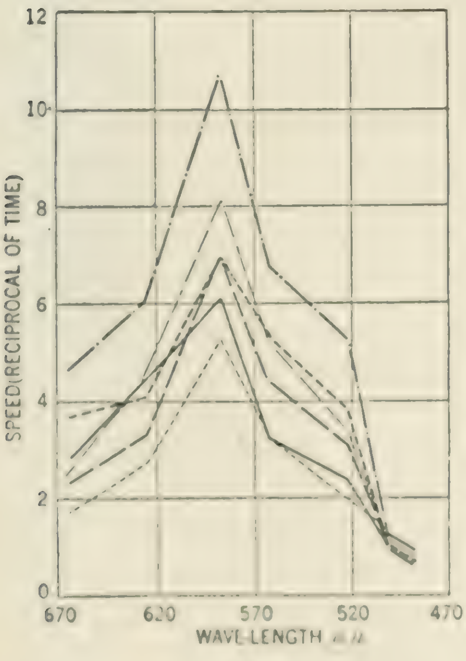


Fig. 9

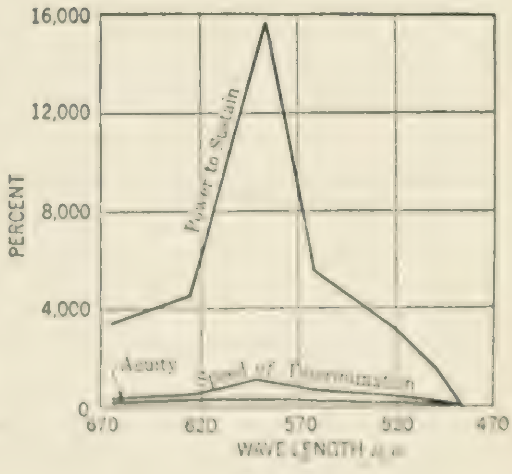


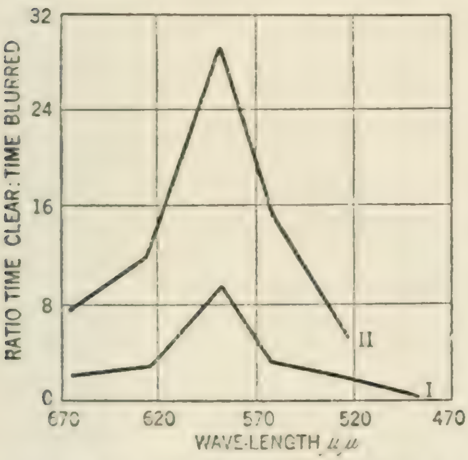
Fig. 10

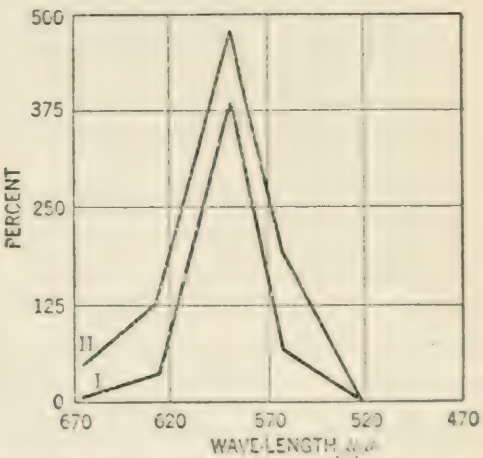
Fig. 9.—The effect of change of wave-length of light on speed of discrimination. Showing the individual results for the six observers, intensity I.

Fig. 10.—Showing the percentage change with change of wave-length of light in all of the functions tested, plotted to the same scale,—intensity I. The value for blue is taken as the base on which to calculate the percentage change.

blue for the lower intensity of light. The value of this angle was 3.664 min. of arc. The test-object was the same as we have always used for the work on power to sustain clear seeing, the printed letters "li," the task being to resolve and hold clear for a period of three minutes the break between the dot and its stem in the letter i. The breadth of the break was 0.6255 mm. and the visual angle subtended by the break at the observer's eye was, as already stated, 3.664 min. of arc. A record was made on a kymograph with a key, electro-magnetic recorder, and Jacquet chronograph of the time the break could be discriminated in three minutes, the measure of the performance of the eye being expressed as a ratio of the time seen clear to the time seen blurred. It could also be expressed as a ratio of the time seen clear to the total time of observation. There being no objective check on the correctness of the judgment, its precision had to be checked up by the size of the mean variation as it is in photometry and other subjective performances in which an objective check is not possible. As in photometry, carefully tested and practiced observers are also needed. The work was done in a dark room. The eye was pre-sensitized to this condition of field by a 50-minute period of adaption. Constancy of position of the eye was secured by having the observer bite a mouth board on which the impression of his teeth had previously been made and hardened in wax. The results of these determinations are shown in Figs. 11 and 12. In Fig. 11, the ratio time clear to time blurred is plotted against wave-length of light. The order of ranking as to power to sustain is the same as for acuity and speed of discrimination with the exception of the ranking of red and green. The acuity and speed were higher for green than for red. In case of the power to sustain the reverse was true. The eye shows better power to sustain its acuity under red light. The ranking from highest to lowest power to sustain for the lower intensity was yellow, yellow-green, orange, red, green, blue-green and blue; for the higher intensity, yellow, yellow-green, orange, red and green. In conducting the test, as has been already stated, a visual angle was selected slightly greater than the minimum for the light giving the lowest acuity. This was the blue of the lower intensity spectrum. Since we wanted to compare the results for the higher and the lower intensity, this angle was

used also for the higher intensity. This rendered the test for the work at the higher intensity considerably less sensitive. That is, for this intensity the visual angle was too large to give maximum sensitivity to the test. It also rendered large the scale of ratios of the time clear to the time blurred at the higher intensity.





Figs. 11 and 12.—Showing the effect of change of wave-length of light on the eye's power to sustain the clear seeing of the test-object for 3 minutes. Intensities I and II. Fig. 11, ratio time clear to time blurred plotted against wave-length; Fig. 12, percentage change in ratio time clear to time blurred plotted against wave-length. The lowest value of power to sustain acuity common to both curves in Fig. 11 is taken as the base on which to calculate percentage change.

As we have already stated, the effect of color on power to sustain acuity is very strong. This came out particularly in the comparison of the daylight glass and the type C lamp with the spectrum colors. For example, the ratio time clear to time blurred for the daylight glass was 71; for the tungsten lamp, 35; and for the yellow of the spectrum, 29.

In Fig. 12 are given curves showing the percentage change in speed with change of wave-length for both intensities of light. In these curves percentage change in the ratio of the time clear to the time blurred is plotted against wave-length. In both cases the lowest value of power to sustain which is common to both curves in Fig. 11 is taken as the base on which to calculate the percentage change. This is the value for green.

For various obvious reasons the foregoing curves were not all plotted on the same scale, nor was the same number of observers used throughout. In order to make possible a comparison of the effect of change in wave-length on the different functions under the conditions tested, Fig 10 is given in which all the curves are plotted on the same scale and represent the results of the same

observer. The curves are plotted for the lower of the two intensities. In all cases the lowest value for all the functions tested was taken as the base on which to calculate the percentage change. For the lower intensity this was the value of the blue.

An inspection of Fig. 10 shows that the functions most affected by the change of wave-length are in order from greatest to least the power to sustain acuity, speed of discrimination, and lastly acuity. So far as we have been able to tell from all of our work up to the present time, this order of ranking holds in general for whatever affects the functional powers of the eye: errors of refraction, favorableness or unfavorableness of working conditions, bodily health and fatigue, etc. From the standpoint of testing, therefore, the power to sustain acuity affords the most sensitive, and the conventional acuity test the least sensitive basis for detecting small functional disturbances in the eye, whether they are due to errors in refraction or any of the causes mentioned above. Speed of discrimination, however, is a very sensitive test and more feasible for general laboratory purposes than power to sustain.

With reference to the problem of the coloration of paper this study shows that wave-length, hue, (which is a subjective aspect of both wave-length and intensity), and saturation (which is also a function of wave-length and intensity) are important factors governing the working powers of the eye. Further analysis, however, is needed. Obviously an important point yet to be determined is the relative significance of hue and saturation. In other words, how much effect is there for difference in color when the working surfaces are equalized in saturation and brightness and conversely how much effect is there for difference in saturation when hue and brightness are made equal? For example, it is quite possible to make papers of different hues and of approximately the same saturation and brightness. What would be the difference in the working powers of the eye under these conditions? We have already made the determination (results as yet unpublished) for fairly well saturated red, yellow, green and blue (mixed lights) with regard to tendency to produce ocular fatigue and discomfort, and have found a very considerable difference. Later this determination will be made for acuity, speed of discrimination and power to sustain acuity.

DISCUSSION

D. McFarlan Moore: The amount of data on this general subject that Dr. Ferree has collected during the last few years is certainly very imposing. I note that he was requested by a paper company to furnish specifications for an ideal printed page, and I would like to ask Dr. Ferree whether he is now in a position whereby he could prepare the ideal specifications for an ideal artificial light, the fatigue factor of which would be equal to or less than the fatigue factor of the best quality of daylight. I am delighted to note that these latest investigations seem to corroborate the opinion of many that the light which most nearly approaches daylight in quality is easiest on the eye.

Louis Bell: I think we are all indebted to Dr. Ferree and his colleague for a very interesting mass of information on some of the reactions of the eye. One thing in particular interested me (and I think that it would be found worthy of some further investigation) and that is, what he refers to as the resolving power of the retina.

Of course, the resolving power of the retina means much. There has been some comment as to whether theoretically the resolving power of the refracting media increases directly as the wave-length shortens. Of course, every microscopist knows what that particular thing in the optical effect is, because in examining, for instance, diatoms in the microscope, it is a perfectly common experiment to show the effect of shortening the wave-length on the resolving power available. It is something startling to see the way that shifting the wave-length toward the blue will immediately raise the resolving power, to a degree that enables details, absolutely invisible otherwise, to be seen with the utmost clearness.

Then there is the effect which was referred to as the resolving power of the photographic plate which is quite distinctly depending largely upon the structure of the plate, on the fineness of the grain. I carried out some experiments in the last year on the fineness of grain in plate; and the difference in resolving power comes out very strikingly with some of the fine process plates, of a structure that is so fine that details can be made out that would be quite impossible to get in high speed plates.

That is a very well-defined, clearcut phenomenon. Now, the resolving power of the retina is a very curious thing which I hope Dr. Ferree will investigate still further. We have there a plate which for any given individual and for fixation in the fovea, is given a definite structure. There is a point, unquestionably, beyond which the size of the retinal structure will quite plainly affect it. Dr. Ferree is working near it.

It seems to me that here we have entirely a different situation entering, which determines the factors of sustained acuity, and that is, the effect of the various wave-lengths on the photochemical substance, whatever it is, which actually determines vision. We know that there is a photochemical substance which is decomposed, giving the fatigue effects, and it seems to me that the retinal action is very much as an ordinary normal photographic plate would act if it were sensitized with unstable dyes.

Ordinarily one tries to get the dyes which will keep fairly well, but if you can imagine a plate sensitized with dyes which were extremely unstable you would then have something corresponding to the retina. Then you would find that the details would depend very much on the wave-lengths of the light because on a fairly long exposure, the sensitiveness of the plate itself, to various regions of the spectrum, would undergo profound change.

It seems to me that is what Dr. Ferree has stumbled upon in these experiments, a perfectly genuine effect due to the result of light of different wave-lengths, falling upon an extremely unstable substance. It is a thing which we do not find in the mere investigations of acuity depending upon the dioptric effects; it is a thing we do not find in photographic plates with any stability at all, but which is predominant in the effect of light on the retina and it would seem that a thorough investigation along this line might give us a good deal of light on the general characteristics of the photochemical substance which determines the effect upon the retina. It involves a distinctly new sort of resolving power. In all these experiments and all others on the eye, it seems rather desirable to carry the intensities a good deal higher than it has been carried here. The experiments on light of different colors, at low intensities and the experiments

carried along on quite the same lines much higher, might lead to some very interesting results.

For example, nothing is more familiar than the fact that detail which is very faint in relation to its background has a totally different acuity reaction from detail where the contrast is large and carrying this particular difference into the experiments on the color effects on acuity, might lead to some very interesting results.

There have been a good many results published by some of the foreign investigators, for example, on the supposed reaction to color of infants, which turned out, after being carefully looked over, to be nothing more than contrasts of apparent intensity. In other words, the child was supposed to be seeing the color, and taking notice of colors, where there was nothing involved at all except difference of contrast of the color with the background, and if this question of chromatic contrast were followed out, I think we would get still another line on the reaction of the eye to color, which, of course, is really just now being investigated, and to which Dr. Ferree has made no inconsiderable contribution.

E. L. ELLIOTT: Mr. Chairman, it is customary to express appreciation of papers that are presented, especially those representing unusual labor and investigation; but I want to go a little farther than the previous speakers have yet gone in regard not only to this, but to the contributions that Professor Ferree and his colleague have been presenting to the Society for a number of years, beginning, as I recall, in 1913.

Papers on the lines of investigation that they report are actually the foundations of illuminating engineering. Illumination, as a branch of engineering, is an applied science; the engineer takes the results of pure science and makes practical use of them. For example, the structural engineer takes the results of the metallurgist and the physicist and uses them in designing bridges and structures. It is not up to the structural engineer to devise new alloys; his function is to take the results obtained by the metallurgist and use them. The illuminating engineer is in a precisely similar position with regard to the work of the physicist and particularly in regard to the work of the

psychologist and physiologist. The physical elements of illuminating engineering are comparatively few, and most of them have been long known. The measurement of light, and the mathematical principles upon which it depends, are certainly not new. The final result that we are after as illuminating engineers, is to enable the eye to see with its maximum efficiency. This does not depend upon what happens outside of the eye, but upon what happens within the human body; and in this field we have little exact knowledge as yet. That is why I say that these papers of Dr. Ferree, and others of a similar nature, are actually laying the foundation of illumination as a science.

It will interest you, perhaps, if I give as briefly as I can, the results of a long series of experiments[1] extending over some eight months of continuous work, in a similar line. In this case, instead of taking discrimination and acuity tests, the results were obtained in reaction time. Reaction time represents a summation of a considerable number of physiological and psychological effects, but it is the thing that the engineer is after. When the workman (and industrial lighting, I take it, is the most important of the two divisions of illumination as an applied science) sees what is before him, and makes a motion, or motions, which are guided by the visual impression, he is giving a practical example of visual reaction time. Probably 75 per cent of all labor is performed by the guidance of the eye; and such as is performed by other guidance does not interest the illuminating engineer.

In the experiments to which I refer, the three kinds of light which are now available, that is, sunlight, the light of incandescent tungsten, and the light of luminescent mercury vapor, were used, at different intensities, representing the practical range of illumination. The test object consisted of numbers consisting of four digits printed in ten point type with black ink on white bond paper. The reaction time recorded was the time it took the observer to read a number and press a key. All necessary precautions were taken to avoid the elements of fatigue, adaptation, and acuity, from entering into the results.

[1] M. Elliott "Comparative Cognitive Reaction time with Lights of Different Spectral Character and at Different Intensities of Illumination." *Amer. Jour. of Psych.*, Jan., 1922, Vol. 33, p. 97.

The investigations were made over a range of intensity from one-half to fifty foot-candles, so that there was attained not only the reaction time under these three different types of commercial light, but also under the different intensities of each light. The results of three observers averaged, and plotted as reciprocals, are shown in the curve. The number of reactions in a given time under daylight at ten foot-candles intensity is taken as 100, and the other reactions reduced to this basis. See Fig. 13.

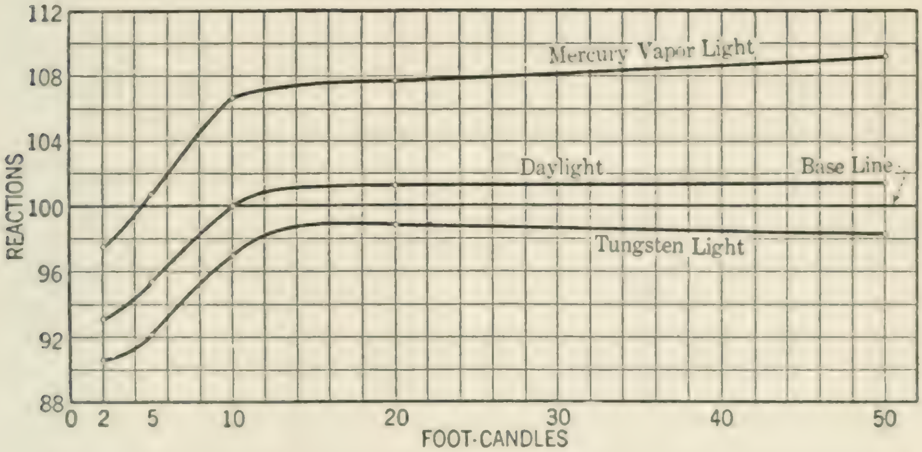


Fig. 13.—Visual reaction time under lights of different spectral character and at different intensities.

The results showed that ten foot-candles in each case was practically the intensity that was most useful. There was a slight rise in the speed of reaction for the mercury vapor light above ten and a slight decrease with the tungsten light above twenty; but the change was small.

This indicates that where we have maximum contrast in objects to be seen, which is of a fineness represented by ordinary type, ten foot-candles is the minimum illumination that should be provided.

The remarkable thing brought out by these experiments is that at all intensities the speed of reaction under mercury vapor light was markedly greater than under either daylight or the tungsten light; the difference at each intensity seemed to be about constant. Mercury vapor light gave about six per cent quicker reaction than daylight, and about twelve per cent quicker than the tungsten light. These results seem to me particularly valuable because reaction time takes in all of the elements and gives us at once a summation of the effects that we are after.

The fact that reaction time is an old and well tried method, and one which has been found useful in many ways, adds materially to the value of the results obtained in the present case. The intermediate steps (cognition, discrimination, etc.) are interesting to the pure scientist, but reaction time gives at once a total result that is the exact equivalent of the visual factor in manual labor; and this is of practical interest to the illuminating engineer.

WARD HARRISON: May I ask Dr. Ferree just what "saturation" means as used in his paper? I did not understand quite clearly what he meant when he said that increasing the intensity of illumination reduced the saturation decidedly.

DR. GEO. S. CRAMPTON: I understand the discussion is closed, but I want to say one word in appreciation of this work that Drs. Ferree and Rand have been doing the past few years. I certainly appreciate it from the standpoint of ophthalmology, and I am sure it is appreciated very much by the gentlemen present. I have the pleasure of living not very far from Dr. Ferree's laboratory and get a chance to see him frequently and can vouch for the very consciencious and accurate work that he and his clever wife are doing.

M. LUCKIESH (Communicated): I wish to compliment the authors on their recent addition to their long series of researches. I am particularly interested in their results obtained with nearly monochromatic light. This is the first work which I have seen on this subject since I published my results ten years ago (*Elec. Wld.*, 1911, 58, p. 1252; TRANS. I. E. S., 1912, p. 135; "Color and Its Applications," 1915), and I am interested to note that their results relating acuity and wave-length agree with mine to the extent that they show as my results did that monochromatic light in the middle of the spectrum near the yellow reveals detail better than light towards the ends of the spectrum.

In my work I used monochromatic light including three of the spectral lines of mercury. I also had a brightness of my colored field equal to that of a white surface illuminated to an intensity of 4.2 foot-candles. The acuity object which I used was that of parallel lines which could be varied as to width and

separation. Ferree and Rand's data were obtained at very low illuminations and the relations might not be considered to hold for higher illuminations. However, the data which I obtained were obtained at what might be considered a normal working intensity so that the relation appears to hold in general throughout the range.

C. E. FERREE: In reply to Mr. Moore I would say that on the basis of the results we have obtained so far on acuity, speed of discrimination, speed of adjustment of the eye for clear seeing at different distances, power to sustain acuity, and ocular fatigue and discomfort, I would be inclined to recommend strongly daylight composition and color values as best all around for the eye. I would be inclined also to make a similar recommendation of daylight intensities when the distribution factors are properly taken care of,—perhaps one should add also, when daylight compositions and color values are approximated. Just how much or whether at all the well-being and efficiency of the eye under daylight intensities depend upon composition and color value as well as upon the distribution factors I am not at this time prepared to say. However, so far as the eye is concerned, I do not think we will go far wrong in taking the well daylighted room as our model with regard to all of the aspects of lighting,—composition and color value, intensity and the distribution factors.

As an illustration of the effect of the resolving power of the refracting media on acuity Dr. Bell cites the superior clearness with which the short wave-lengths of light bring out details in the microscopic field. While microscopy undoubtedly serves as a good means of demonstrating or illustrating the factors which influence the resolving power of refracting media, it is apt to be misleading and confusing as to the relative importance of these factors in vision without the microscope as an accessory. That is, in the latter case the eye views its object directly, not an image of the object formed by an accessory refracting system as in microscopy. In microscopy, therefore, the relative importance of refractive resolving power and of the factors which influence it is greatly amplified and exaggerated as compared with their importance in ordinary vision. The microscope is in fact just

an amplification or extension of the eye's refracting system. It does not affect the resolving power of the retina. A discrepancy should not be surprising, therefore, between the effect of wave-length of light on acuity as represented in the natural power of the eye, and in the eye whose refracting powers are amplified by means of a microscope. In one case it would appear the resolving power of the retina is dominant; in the other the resolving power of the refracting system.

Dr. Bell seems to believe that wave-length of light in relation to fineness of structure of the retina may be of considerable importance in explaining the effect of wave-length on the resolving power of the retina. So far we have been inclined to explain this effect largely in terms of the subjective factors hue and saturation. That is, even when all are made equal in brightness, black test characters seem to stand out more distinctly,—to have a greater qualitative difference as sensation from some hues and saturations as background than from others. However, the point is an interesting one for investigation. Our next series of experiments will, we hope, present differential evidence for and against hue and saturation as factors.

The suggestion that the effect of wave-length on the ability of the retina to sustain its resolving power is due to a difference in power progressively to disintegrate an unstable visual substance is an interesting one. If this be true and it be true also that the difference in the rate of disintegration affects seeing, it should show out in experiments conducted to determine the relative rate of exhaustion or adaptation of the eye, achromatically and chromatically, to the different wave-lengths.[2] Such experiments for the chromatic response have already been conducted in our laboratory for the same wave-lengths as were used in the foregoing experiments. They will be conducted in the near future also for achromatic response. We have noted in the text the importance of the "streaming phenomenon" as a factor in the ability of the retina to sustain its resolving power. (For a description and discussion of this phenomenon, see "The Intermittence of Minimal Visual Sensations," *Amer. Jour. Psychol.*, 1908, XIX, pp. 59–129; and the "Streaming Phenome-

[2] This progressive disintegration and the differential action of wave-length of light upon it might of course also lie at the foundation of the "streaming phenomenon" and its greater activity under some wave-lengths than others.

non," *Ibid*, pp. 484–503). The conclusion that this phenomenon influences the blurring of details in the test-object and that the activity of the streaming is greater for some wave-lengths than for others is not based on speculation or inferential grounds. It is directly observable.

For many years Dr. Bell has adventured with success in the "no-man's land" between the physical and the conscious in the subject of optics. In replying to his discussion, therefore, I could perhaps say nothing more fitting than to suggest that he help out in the investigation of some of the interesting points he has raised.

I agree with Mr. Elliott with reference to the importance of investigations having for their purpose ways and means of best adapting light to the use of the eye. I would not perhaps go as far as he has in the relative importance which he assigns to the work of the psychologist and the physiologist in illuminating engineering. Nor would I agree with him at all with regard to the comparative merits of the procedure which he has selected to make his studies. Mr. Elliott says: "The final result we are after as illuminating engineers is to enable the eye to see with its maximum efficiency." If this be true then it is our business as investigators to find out what conditions are most beneficial to seeing and to use as procedure test methods which measure the effect on the most important aspects of seeing, such as acuity, power to sustain acuity, speed of discrimination, etc. But we need not include in our test procedure the measurement of any or all of the body's actions or reactions which seeing touches off; for, so far as our present knowledge goes or any probability based on knowledge which we now possess, a lighting condition does not affect the response of a muscle in any other way than through its influence on the eye's response. Why not then if we are concerned in finding out what affects the speed of the eye's response, as we are in the case that has been presented by Mr. Elliott, measure the speed of this response directly? Why include in the interval measured the additional time required for the response of a muscle, which response is not of itself affected by the conditions under investigation and adds into the interval a large and irrelevant constant component which serves only to mask and conceal changes in the component in which we are

interested, namely, the eye's speed of discrimination? To add in the time required for the simple reaction of pressing a key certainly contributes nothing to the solution of our problem not already contained in the measurement of the speed of visual discrimination; moreover, it adds to the time required for that discrimination a greater constant time which masks the effect and serves only to render the test insensitive and of low precision.

There is, it is true, as an adjunct to the problem of lighting in relation to the eye, a possibility of finding out how far clear seeing is important to this or that type of work and, therefore, of how much importance differences in lighting conditions are to various types of work. This, I infer, is the problem which Mr. Elliott has in mind. Such knowledge could not be gained, however, merely by measuring the time required for one degree of clearness of discriminating a test-object or group of test-objects, and for so simple and non-specific an action as pressing a key. It could be had only by embodying in the experiment as visual task and reacting movement, some important item of the work under investigation. Such a test is of the nature of a specific performance or special service test and in order to apply it to lighting in relation to industry, which seems to be the special problem which Mr. Elliott has selected from the larger field, as many varieties of test performances are needed as there are in the industries types of work requiring different degrees of clear seeing, speed of seeing, etc. The whittling down of the reacting movement, for example, to the mere pressing of a key takes away all the special meaning or service of adding a reacting movement to the experiment. It becomes merely a clumsy way of recording the speed of making the visual discrimination,—a way of recording too that adds in to the interval measured the time of making the movement, which time is larger in most cases than the time of making the visual discrimination itself.

The reaction time experiment has been in use for more than a hundred years and has been employed in one form or another as a measure for almost everything that has come within the range of psychological testing from the effect of alcohol, tobacco and drugs to the detection of feeble mindedness and the various types of insanity. It has been Mr. Elliott's privilege here to present the experiment in still another rôle. In this connection

it may be pointed out that a test the results of which are influenced by so many factors that it may be used with apparently equal facility for many purposes, is open to the charge of being of no particular or special value for any one of these purposes. To say that the reaction time experiment in the present instance is open to this charge is not entirely unfair. That is, when used as a means of picking up differences in the conditions which affect the speed of making the visual discrimination, this experiment is insensitive and of low precision to a degree which is very undesirable and entirely unnecessary. It is insensitive because, as I have already pointed out, the interval measured includes the time of making both the visual discrimination and the reacting movement. The time for making the reacting movement is longer for all but very low intensities of light than is the discrimination time, and is probably very little if any affected by the optical conditions which affect the discrimination time. A component more or less constant, therefore, so far as optical conditions are concerned, is included in the quantity measured, which masks in the total result the changes in the variable component which it is our problem to detect. It is of low precision in the first place because of its low sensitivity; and in the second place because it is subject to the influence of a number of extraneous variable factors which serve to give it a high mean error, much higher for example than the discrimination time experiment. I have been very much surprised to note that during the war the reaction time experiment was used in several cases where the important quantity to be measured obviously was the discrimination time alone. This, however, was probably due to war emergency conditions. That is, a method and apparatus for measuring the visual discrimination time had not yet been devised and the reaction time was used as an available emergency substitute.

One of the sources of variable results in the reaction time experiment not found in the simple visual discrimination experiment is the direction of the observer's attention. Attention may be directed to the sensory stimulus, to the reacting movement, or possibly somewhat diffusely given to both. When the attention is directed to the stimulus, the reaction time has been found

to be longer than when directed to the reacting movement. Lange, for example, found that the reaction time to visual impressions (simple light impressions) when attention was directed to the stimulus rather than to the reacting movement was 0.29 sec.; when the attention was directed to the reacting movement it was 0.113 sec. That is, the value of the first result is more than twice that of the second and the only difference present was in the direction of the attention. There was no change in the objective conditions of the experiment. The first type of reaction has been called the sensory reaction; the second, the motor reaction. The motor type of reaction has the smaller mean variation. The variability of result is no doubt in part due to the difficulty of maintaining constancy of the type of reaction; there seems to be a tendency varying with the individual reactors for the sensory to pass over into the motor type The individual differences or variability of results may also be due in part to a natural tendency to direct the attention one way or another.

The emphasis in the reaction time experiment is on the time required for some muscle of the body to give a response,—not the sense organ. The response of the sense organ is tolerated only as a means of causing the muscle to react, an objectionable but necessary element in the procedure. That is the time required for the muscle to react can not be measured without including also the time required for the response of the sense organ. The converse, however, is not true. We can measure the time of response of the sense organ without including the time needed for making the various movements which it might be used to set off. In Mr. Elliott's work the traditional emphasis in the reaction time experiment is reversed. He is concerned with the speed of response of the sense organ, but he is willing to tolerate the inclusion of the response of the muscle although, so far as our present knowledge goes, that is a factor which is entirely irrelevant. This inclusion would be more justifiable if it were necessary, but it is wholly unnecessary. A much more precise measurement can be made of discrimination time than of reaction time. I do not mean to say that there are not good

uses for the reaction time experiment,—commendable uses have been found for it, as Mr. Elliott has pointed out; but I do contend that it is a poor substitute for the speed of discrimination experiment in the investigation of the effect of lighting conditions on the eye or of lighting in relation to industrial work when the experiment is used in the form selected by Mr. Elliott. But if we are to use it for these purposes, let us by all means be frank and call it reaction time as Mr. Elliott has done, not speed of discrimination as one writer has recently shown a tendency to do. The only way it could be called a speed of discrimination experiment is by recognizing that the time of making the record is added to the result. In our own measurements of speed of visual discrimination, the time of making the discrimination alone is measured. That is, the tachistoscope (rotary) was set by trial to give the smallest exposure in which the discrimination could be made, and the value of this exposure was measured. After the exposure was made the observer reported verbally whether the opening of the circle pointed up, down, right, left or any of the 45-degree positions. The time of making the report was not included in the result measured.

Considerations of the kind noted above have always led us to reject without hesitation the reaction time experiment in all work in which our problem is to investigate the conditions which affect the speed of response of the eye. An example of a better selected use of the reaction time experiment in relation to industrial work is the rating of the fitness of individuals for different types of work on the basis of their speed of reaction. Here the variable about which knowledge is wanted is measured directly; the incisiveness of the experiment is not mutilated by the presence of needless irrelevant factors.

My dominant interest in the experiments reported by Mr. Elliott is in the method used, not in the lights compared. In scientific work methods are of importance first because faulty methods give faulty results. Yet I can not help but wonder how significant a difference in result of 6 or even 12 per cent should be considered when obtained by a test which may yield, according to Lange, a difference of 100 per cent, depending upon the direction of the attention alone. I scarcely need point out that

in the use of the reaction time experiment unusual care should be exercised in checking up the precision of the work, in the instruction and training of the observer, and in the interpretation of the results. All of this, I presume, has been done in these experiments. The great objection to the use of a test of low sensitivity and of still lower precision is the difficulty of getting differences in result, due to changes in the conditions tested, which are safely in excess of the mean error of the test. I have not, for example, recommended the speed of adjustment for clear seeing at different distances as a test of the effect of lighting conditions because of the presence of the more or less constant muscle factor, which renders the test unduly and unnecessarily insensitive as compared with the speed of discrimination test. And in this test, too, the presence of the muscle factor is not as objectionable, so far as the reduction of precision is concerned, as it is in the reaction time experiment because in it the muscle reaction is reflex or automatic and is not subject to a variable influence due to the direction of the attention.

Mr. Harrison has asked just what saturation means as used in our paper. We have not used the term in any exceptional sense. It is often defined as the ratio or proportion of the chromatic to the achromatic component in the color sensation. The subjective aspects hue, saturation and brightness all vary with the variation of the intensity of the colored light. At very low intensities all colored lights are seen as colorless. As the intensity is increased color appears. In case of red the color component comes in very soon. That is, for red the so-called photochromatic interval is very slight. This interval varies in magnitude in different parts of the spectrum, reaching its maximum in the neighborhood of the yellow-green and green. When color has once appeared, further increase of intensity causes an increase of saturation for the greater part of the spectrum, also a change in hue,—until a point of maximum saturation is reached. The physical intensity at which this maximum is reached varies quite a great deal for the different parts of the spectrum, also the actual value of the saturation for different eyes. The point of maximum saturation comes for all colors quite low in the scale of intensities measured

either radiometrically or photometrically. A further increase of intensity beyond the point of maximum saturation results in a decrease in saturation,—also again a charge in hue for the greater part of the spectrum. With increase of intensity the short wave-lengths become colorless or white before the long wave-lengths. Red and orange, for example, become white only at very high intensities. Both tend to become yellow before passing into white. In studies soon to be published from this laboratory sensation has been laid off in just noticeably different steps in different parts of the spectrum from the achromatic threshold to very high intensities, the changes noted, and the points at which they occur in the intensity scale specified photometrically and radiometrically. These specifications have been made also for the point at which the maximum saturation occurs.

In reply to Dr. Crampton I would say that the work done at the Bryn Mawr laboratory has been greatly aided by our proximity to Dr. Crampton and other interested and able Philadelphia ophthalmologists. I am glad he has given us this opportunity publicly to acknowledge our indebtedness to a group of men whose service to ophthalmology and its associated interests makes Philadelphia one of the greatest eye centers in the world.

As I remember, Mr. Luckiesh conducted two sets of experiments for the rating of spectrum acuities, a nearly monochromatic series for points in the spectrum of a tungsten lamp between 660–500 $\mu\mu$, and a monochromatic series for three points (578, 546 and 436 $\mu\mu$) in the spectrum of a mercury-vapor tube.

The work on spectrum acuities was repeated by us partly in verification of the results obtained by Mr. Luckiesh, but mainly that we might have a basis of comparison of acuity, speed of discrimination and power to sustain acuity for the same observers and conditions. The lights used by us were narrow bands selected from the spectrum by a slit 0.5 mm. wide. They were of such a degree of purity that when the test surface illuminated by them was examined by means of a small Hilger spectrometer no alien bands were revealed. That is, the alien bands which were in the spectrum beam were reduced below the

threshold of sensation in the reflection from the surface of the test-object. Ordinarily it is our custom to filter out the alien bands usually found in a lens-prism spectrum, but in this case we wanted all of the intensity available; moreover, as already stated, impurities were not found in sensible amounts in the light reflected from the test surface. I infer that alien bands were present in the higher intensity beam entering the eye in Mr. Luckiesh's first series of experiments, since no statement is made of filters or other devices having been used to eliminate them. However, while the presence of these low intensity bands would be of considerable importance in case of sensory determination, it is quite probable that they are of negligible importance in determinations of acuity.

INTERIM REPORT OF COMMITTEE ON MOTOR VEHICLE LIGHTING

PREFACE

The first specifications for tests of headlighting devices for approval by state authorities were put forth by this Committee in 1918. These were admittedly of a very lenient and tentative character. On account of the meager amount of laboratory data and of practical experience on the road which were available at that time, it was necessary that the specifications should not be made too hard and fast, but that they should be drawn with a view to future improvement as experience might show necessary. Accordingly a further revision was effected in 1919, and a revised edition of the rules was put out under date of May, 1920. This revision showed marked improvements in the specifications, and was adopted by a considerable number of states.

Since that time further experience has accumulated in this field, particularly as a result of the adoption by the State of Massachusetts of specifications for laboratory tests which in some respects went further than those of the I. E. S. Committee, and the application of which was attended with good results. It became clear from the situation, that the I. E. S. specifications required further improvement, and that the data upon which such improvement could be based had become available as a result of a large number of tests made for various states, the results of which tests had become matters of public record. The Committee on Motor Vehicle Lighting has therefore gone over its specifications very thoroughly, and presents herewith a revised edition of them.

It should be specifically pointed out that these revised rules prescribe tests which can be made only in a photometric laboratory equipped with precise measuring instruments and photometric standards. These rules for laboratory testing are much too complicated to be applied to tests of headlights on the road, and are not intended so to be applied. The present amplification of the acceptance test is a natural result of the development of the art, and is designed as a more complete method of excluding inferior devices.

In putting forth this revision it is not the intent of the Committee that headlighting devices which have passed tests under the older specifications and have been approved, ought necessarily to be removed summarily from approval lists. The Committee, without of course having any jurisdiction in the matter, respectfully submits that in fairness to all, a time interval should be allowed and announced, at the expiration of which all devices which do not comply with the revised specifications should no longer be permitted to be used.

COMMITTEE ON MOTOR VEHICLE LIGHTING 1921-1922

F. C. Caldwell
G. N. Chamberlain
P. W. Cobb
E. C. Crittenden
A. W. Devine
J. A. Hoeveler
W. F. Little
W. A. McKay
A. L. McMurtry
H. H. Magdsick
L. C. Porter
C. H. Sharp, *Chairman*
G. H. Stickney
L. E. Voyer

RULES GOVERNING THE APPROVAL OF HEAD-LIGHTING DEVICES FOR MOTOR VEHICLES

COMMITTEE ON MOTOR VEHICLE LIGHTING
ILLUMINATING ENGINEERING SOCIETY

Revised February 9, 1922

DEFINITION

By headlighting device is meant either the integral and complete headlamp or a device intended to modify in a suitable manner the beam of the ordinary type of headlighting equipment.

REQUIREMENTS FOR APPROVAL

No headlighting device will be approved until it has been submitted to a laboratory test as prescribed in Section I through which it is shown to be capable of conforming to the requirements as to production and distribution of illumination. Furthermore it must satisfy the additional conditions which are laid down in Section II entitled "Approval." The laboratory test will be made by a competent and unbiased testing authority satisfactory to the State Authority.

I. LABORATORY TESTS

(A) TESTS OF DEVICES USED IN PAIRS

Samples for Test

The samples submitted to the testing authority shall be representative of the device as manufactured and as marketed. They shall be accompanied by printed instructions for their use as issued by the manufacturer of the device. The samples submitted shall include as much of the accessory equipment peculiar to the device (except batteries) as is necessary to operate the device in its normal manner. In the case of front glasses the samples shall be one pair each of $8\,^5/_{32}$ (or Ford size) 8½, 9 and 9½ inch diameter when practicable.

Reflectors and Incandescent Lamps

In the case of devices to be used in connection with standard parabolic reflectors, the reflectors used in making the laboratory tests shall be of standard high grade manufacture of 1.25 inch focal length with clean and highly polished surfaces, and as nearly truly paraboloidal in form as practicable, and as approved for this purpose by the National Bureau of Standards.

The incandescent lamps used in connection with the laboratory test shall be of standard manufacture and as approved for this purpose by the National Bureau of Standards. In the case of devices involving the use of special incandescent lamps, such lamps together with any necessary accessories shall be submitted.

Marks of Identification

Each device submitted must bear a distinctive designation prominently and permanently indicating the name and type of the device. Special incandescent lamps submitted in connection with devices shall bear the manufacturer's normal, clear bulb rating.

Adjustment of Devices

The testing authority shall adjust the device in accordance with the printed instructions issued by the manufacturer, which instructions must be adequate for practical purposes. An exact description of the adjustment made for test shall be given in the report.

Focal Adjustments of Incandescent Lamps

The following designations of the focal adjustments of the incandescent lamp in the parabolic reflector are adopted:

Principal Focus. The beam, with bare reflector or plain front glass, is nearly parallel and of the smallest possible diameter.

Rear Focus. The beam, with bare reflector or plain front glass, diverges as much as possible without having a dark center.

Front Focus. The beam, with bare reflector or plain front glass, converges and crosses near the lamp and then diverges as much as possible without having a dark center.

Special Focus. A special focal adjustment is allowed only when it can be clearly defined and described.

Photometric Tests

The tests shall be as follows:

TEST I

A pair of testing reflectors, mounted similarly to the headlamps on a car, shall be set up in a dark room at a distance of not less than 60 feet nor more than 100 feet from a vertical white screen. If a testing distance of 100 feet is taken, the reflectors shall be set 28 inches apart from center to center, and if a shorter testing distance is taken, the distance between reflectors shall be proportionately reduced. The axes of the lamps shall be parallel and horizontal, or tilted in a vertical plane in accordance with manufacturer's adjustment. The intensity of the combined light shall then be measured with each pair of samples in turn, with the reflectors fitted with a pair of incandescent lamps of the gas-filled type, 6-8 volts, 21 scp. rating. The lamps shall be such as will give their rated candlepower when operated at their rated efficiency. They shall be operated at their rated candlepower.

Measurements shall be made at the following points at the surface of the screen:

A. In the median vertical plane parallel to the lamp axes, on a level with the lamps.

B. In the median plane one degree of arc below the level of the lamps.

C. In the median plane one degree of arc above the level of the lamps.

D. Four degrees of arc to the left of the median plane and one degree of arc above the level of the lamps.

PL and PR. One and one-half degrees of arc below the level of the lamps and three degrees of arc to the left and to the right respectively of the median plane.

QL and QR. Three degrees of arc below the level of the lamps and six degrees of arc to the left and to the right respectively of the median plane.

A diagram of test positions is shown in Fig. 1.

All pairs of samples tested under the conditions prescribed above shall conform to the following specifications for observed apparent candlepower:

Point A, not less than 1,800 candlepower nor more than 6,000 candlepower.

Point B, not less than 7,200 candlepower, and there shall not be less than 7,200 candlepower at any point on the horizontal line through B, one degree to the left and to the right of B.

Point C, not over 2,400 candlepower, and not less than 800 candlepower.

Point D, not over 800 candlepower.

Points PL and PR, at each of these points and at every point on the line between them, not less than 5,000 candlepower.

Points QL and QR, at each of these points and at every point on the line between them, not less than 2,000 candlepower.

NOTE: The above testing directions are drawn specifically to cover the case of devices accessory to parabolic reflectors of 1¼ inch focal length. In the case of other classes of devices where these directions evidently cannot be applied literally, their intent must be adhered to and the testing positions and candlepower limitations shall govern in all cases.

Acetylene headlamps as at present constructed do not give a beam distribution of the character covered in these rules.

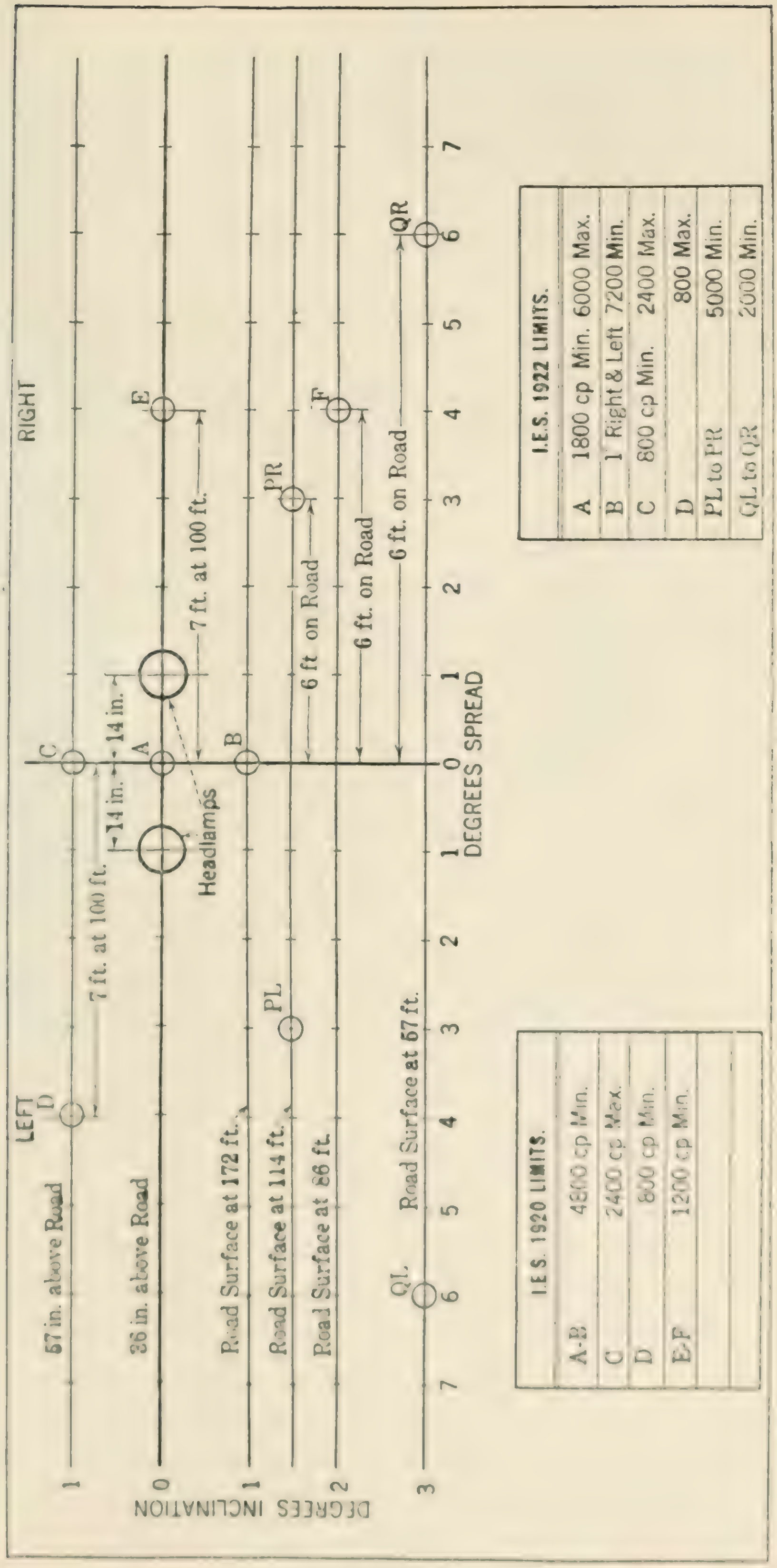


Fig. 1.—Diagram of Test Positions.

Test 2

A single pair of samples taken as an average representative of the device as manufactured, shall be submitted to a complete test with the same testing equipment as specified for Test 1. This test shall show the light distribution characteristics by actual measurements made in accordance with the best laboratory practice.

Distribution of Samples

One pair of the samples submitted shall be retained at the testing laboratory for the purpose of future reference and as samples of construction.

(B) TESTS OF DEVICES USED SINGLY

Motor cycle headlamps are used singly and not in pairs, and have commonly a reflector of smaller diameter and shorter focal length. Hence devices for use in connection with them are not included in the same classification as those for other motor vehicles. For the laboratory tests of such devices two samples of representative sizes shall be submitted. They shall be tested with representative motor cycle headlamp reflectors. The numerical limitations of apparent candlepower for Test 1 with one lamp only shall be as follows:

Point A, not less than 1,800 candlepower.

Point B, not less than 3,600 candlepower, and there shall not be less than 3,600 candlepower at any point on the horizontal line through B, one degree to the left and to the right of B.

Point C, not more than 2,400 candlepower

Point D, not more than 800 candlepower.

Points PL and PR, at each of these points and at every point on the line between them, not less than 2,500 candlepower.

Points QL and QR, at each of these points and at every point on the line between them, not less than 1,000 candlepower.

Test 2 shall be made with one lamp and not with two.

Other deviations from the details of procedure are obviously made necessary because of the fact that single devices instead of pairs are subjects of test.

Reports

The report of the test shall be rendered in duplicate to the State Authority and shall be signed or initialed not only by the expert making the test, but also by an executive officer of the institution making the test.

II. APPROVAL

No device shall be approved which does not pass the laboratory tests.

No device involving the use of a tilting reflector shall be approved unless it conforms with these specifications in its "tilted up" position and has an extreme tilting range of no more than three degrees.

The State Authority reserves the right to refuse approval of any device which in his opinion is liable for any reason to prove unsafe or unsatisfactory in practice. Among the defects which may cause rejection under the above rule are the following:

Unnecessary loss of light due to absorption or diffusion.

Abnormal or unduly complicated adjustment

Unstable or bad mechanical construction

Unduly bright or dark areas or excessive contrast in the illuminated field.

Irregular or badly defined cut-off line.

III. ALTERATIONS IN DESIGN

In the case that the design or construction of any device is changed in any way which alters the characteristics by which it is ordinarily identified, a new name or type designation must be given and the device may then be submitted for approval on the same basis as a new device.

An alteration in the design of an approved device which does not affect its distinctive appearance, but which is made for the purpose of improving its performance, or to correct for alterations made in the standards of construction of incandescent lamps or reflectors, may be allowed under the original approval of such device, provided that due notice of such alteration is given to the State Authority and verification tests satisfactory to the State Authority are made, which show that the device as altered complies with these specifications.

IV. VERIFICATION TESTS

As a safeguard against deviations of the design and construction of an approved device from that on which approval was originally based, the State Authority reserves the right to submit from time to time samples of approved devices to the testing authority for a verification of their performance, or to require the submission at suitable intervals of certified copies of reports of such verification tests satisfactory to the State Authority made by a person or an organization fulfilling the requirements of a testing authority. In case copies of verification tests are not submitted as required, or in case the verification test shows failure of any device to conform to the specifications, the State Authority may suspend or withdraw approval of such device.

SOCIETY AFFAIRS

SECTION ACTIVITIES

NEW YORK

Meeting—February, 1922.

The New York Section met at the Engineering Societies Building on February 16, Mr. William J. Goodwin of the Society for Electrical Development presented a paper, "The Aims and Objects of the Illuminating Engineering Society," and Mr. Frank W. Smith, First Vice-President of the N. E. L. A. spoke on the subject "Better Lighting, Better Business Campaign."

The papers were discussed in full and a good deal of interest and enthusiasm was evidenced. The topics of the evening were so popular that at the close a motion was offered and passed to the effect that the I. E. S. appoint a committee to confer with the Society for Electrical Development and the N. E. L. A. with an idea of discussing ways and means to bring about a co-operative effort between the three societies to assist all concerned in the advancement of business in the electrical field.

There was a total attendance of one hundred and sixty, of this number there were fifty guests.

CHICAGO

Meeting—January, 1922.

The Chicago Section held a joint meeting on January 20 at the rooms of the Western Society of Engineers. The following societies participated in the meeting; American Society of Heating and Ventilating Engineers, Chicago Safety Council, Western Society of Engineers, and Western Efficiency Society.

The following subjects were presented for discussion: "The Status of Factory Sanitation, Ventilation, Safety and Illumination in Illinois," by Mr. R. W. Hamilton of the Illinois Department of Labor.

The purpose of the meeting was to get some organized effort behind the development of a lighting code in the state of Illinois and speakers from the various organizations mentioned talked on this subject and a committee was formed consisting of three representatives from twelve organizations.

There were in attendance twelve members and twenty-five guests.

PHILADELPHIA

Meeting—February, 1922.

The Philadelphia Section met on February 14, at 8:00 P. M., in the Engineers' Club to hear a paper, "The Principles of Illumination Design," presented by Mr. E. A. Anderson, of Cleveland, Ohio.

Mr. Anderson explained the various steps taken in the study and design in illumination for any given building. The paper was illustrated by the use of apparatus showing the effect of lighting under different conditions.

The paper was discussed by several members and guests, and many interesting points were mentioned, among which were the problems confronting the

architect. About seventy members and guests were in attendance and prior to the meeting the usual dinner was held at the Engineers' Club.

TORONTO CHAPTER

Meeting—January, 1922.

The Toronto Chapter met on January 16 at the Chemistry and Mining Building of the University of Toronto to consider a paper, "Nitrogen Lamps," presented by Mr. Watson Kintner, Westinghouse Lamp Works of Hamilton, Ont.

Mr. Kintner exhibited samples of lamps and gave the history of the recent tungsten filament as used in Type B lamp. The steps made in research work on the gas-filled lamp was discussed and lantern slides of the processes involved in the manufacture of lamps were shown.

A very interesting discussion, pertaining to commercial and operating questions, followed the presentation of the paper. There were present fifteen members and thirty-five guests.

COUNCIL NOTES

ITEMS OF INTEREST

At the meeting of the Council on February 9, 1922, the following were elected to membership:

Seven Associate Members

ARCHIBALD DOUGLASS BELL,
Lighting Service Dept.,
Edison Lamp Works of G. E. Co.,
Harrison, N. J.

WILLIAM E. CLEMENT,
Commercial Agent,
New Orleans Railway & Light Co.,
201 Baronne Street,
New Orleans, La.

ROBERT E. GREINER,
Illuminating Engineer,
Edison Lamp Works of G. E. Co.,
Harrison, N. J.

WALLACE ROSS HILTON,
Sales Manager, Illuminating Division,
Northern Electric Company, Ltd.,
121 Shearer Street,
Montreal, Quebec, Canada.

W. H. RADEMACHER,
Illuminating Engineer,
Edison Lamp Works of G. E. Co.,
Harrison, N. J.

C. RAYMOND SMITH,
Electrical Engineer,
Southern Sales Representative,
Charles V. Daiger, Boston, Mass.,
Roslyn Apartment, Bateman and Roslyn Avenues,
Baltimore, Maryland.

DENT A. TAYLOR,
Northwood Glass Company,
Wheeling, Virginia.

Seven Members

SAMPSON K. BARRETT,
Assistant Professor of Electrical Engineering,
New York University,
New York, N. Y.

E. L. Gross,
President,
Gross Chandelier Company,
2036 Morgan Street,
St. Louis, Mo.

Watson Kintner,
Factory Engineer,
Canadian-Westinghouse Co., Ltd.,
Hamilton, Ontario, Canada.

Ernest Fox Nichols,
Director of Pure Science,
National Lamp Works of G. E. Co.,
Nela Park,
Cleveland, Ohio.

George Stanley Phelan,
Industrial Electrical Engineer,
247 Maple Street,
Holyoke, Mass.

Orville R. Toman,
Bedford Light, Heat and Power Co.,
215 Main Street,
Bedford, Iowa.

Clyde P. Trueax,
Wolf, Sexton, Harper & Trueax, Inc.,
7 West Madison Street,
Chicago, Illinois.

Two Members Deceased

The General Secretary reported the deaths of the following members:

Wm. H. Bradley,
Chief Engineer,
Consolidated Gas Company,
130 East 15th Street,
New York, N. Y.

Ernest L. Munger,
Gloucester Electric Company,
26 Vincent Street,
Gloucester, Mass

CONFIRMATION OF APPOINTMENTS

The Council confirmed the appointment of Mr. W. E. Clement as a member of the Committee on Membership.

Advisory Committee on Illumination.—The Council moved that such a committee be organized with the Research Committee as a nucleus and that Dr. E. P. Hyde be asked to suggest members from other interests.

COMMITTEE REPORTS

Committee on Editing and Publication.—A report was read from Mr. N. D. Macdonald, Chairman of the Committee on Editing and Publication, in which he stated that the plan for changing the Transactions to a monthly issue is being put into effect.

Committee on Membership.—Mr. G. B. Regar, Chairman, gave a brief progress report of the work of this committee. An additional appropriation was requested. The Council authorized an increase of an amount not to exceed $75 for the use of the Committee.

Committee on Education.—Prof. F. C. Caldwell, Chairman, reported that the educational exhibit at the Fixture Market held in Milwaukee from January 30th to February 3rd had proved a great success and gave details of the I. E. S. participation.

Prof. Caldwell reported that a meeting of the Committee on Education had been held in Milwaukee on February 1st for the purpose of considering the situation with regard to the extension course, upon which a sub-committee with Mr. Vaughn as chairman had been working

The Council accepted this report and moved to adopt a resolution expressing the thanks of the Society to the Lamp

Companies and their representatives for their co-operation in this exhibit at the Milwaukee Fixture Week. The General Secretary was instructed to send copies of the resolution to the respective companies.

Committee to Prepare a Bulletin of Residence Lighting by Electricity.—Mr. S. G. Hibben, Chairman, reported that the Bulletin is being prepared for printing and copy will be ready in the near future.

The Council authorized the publication of the proposed Bulletin on Residence Lighting by Electricity at the earliest possible moment, subject to the approval of the Committee on Papers.

Committee on Papers.—A report was read from the Committee on Papers in which several recommendations were made, all of which were in sympathy with the feeling of the members of the Board. Copies of the report are to be sent to each member of the local Papers Committees for their consideration and guidance.

Committee on Sky Brightness.—The presented report stated that measurements were made in Chicago during the month of January through the smoke cloud that usually covers the city.

A summary has been prepared of measurements of starlight, moonlight, and twilight.

Measurements of daylight are being made in Cleveland.

Reflection of light from street surfaces and walls of buildings is being studied in New York City.

NEWS ITEMS

At the meeting of the Council held on February 9, 1922, the General Secretary was instructed to write those Societies and other organizations who have not expressed a definite opinion on the question of adopting the term "Luminaire;" and to advise them that the National Council of Fixture Manufactures had recommended its adoption.

Definite action will be taken by the Council of the I. E. S. at the March meeting.

GENERAL OFFICE NOTES

Reprints of the "Code of Lighting School Buildings" as issued in 1918 can be obtained from the general office. Price 25 cents per copy, discounts will be allowed for orders greater than fifty copies upon application.

Reprints of the "Code of Lighting, Factories, Mills and other Work Places" as published in the November 20th issue can be obtained from the General Office. There has been incorporated in the pamphlet a table of contents and an index. Price 25 cents per copy.

The following discounts will be allowed on orders in quantity:

50 copies, discount of 10% per copy.
100 copies, discount of 20% per copy.
200 copies, discount of 30% per copy.
500 copies, discount of 35% per copy.
1,000 copies, discount of 40% per copy.
2,500 copies, discount of 45% per copy.
5,000 copies, discount of 50% per copy.

Copies of the following issues are desired:

Vol. XIV, No. 9, Dec. 30, 1919.

Vol. XV, No. 7, Oct. 10, 1920.

Vol. XVI, No. 3, April 30, 1921.

The General Office will pay fifty cents each for copies in good condition of these issues.

PERSONALS

Mr. Walter D'Arcy Ryan of the General Electric Company, Schenectady, and well-known for his illuminating design and installation in connection with the Panama-Pacific Exposition, returned to this country from Rio de Janeiro on January 24. Mr. Ryan had been in Rio to plan and design the complete illuminating features of the Brazilian Exposition which opens in Rio on September 7.

Mr. Samuel G. Hibben has recently been appointed Manager of the Illumination Bureau of the Westinghouse Lamp Co., with offices at 165 Broadway, New York. In this new position he will have charge of matters in connection with lamp applications, lighting specification practice, photometry and illumination surveys, bulletins and technical publicity, and all general activities of the Westinghouse Companies that are connected with lighting service.

Mr. Hibben, who has been a member of this Society since 1910, is closely identified with illuminating engineering practice, in both this and a number of other technical societies. His former activities include five years as illuminating engineer of the Macbeth-Evans Glass Co., of Pittsburgh; design engineer for the Westinghouse Electric and Manufacturing Company; consulting engineer, Pittsburgh; and several years as illuminating engineer for the Westinghouse Lamp Company.

During the war he had charge of field searchlight engineering in Washington, later operating with the Engineer Corps in France, and he has retained his reserve officer's status as Captain of Engineers, U. S. Army.

ILLUMINATION INDEX

PREPARED BY THE COMMITTEE ON PROGRESS.

An index of reference to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

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TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

VOL. XVII MARCH, 1922 NO. 3

I. E. S. Headlighting Specifications The Basis for Uniform Regulation

SIX YEARS AGO the conditions of automobile headlighting were such that night driving was distinctly unpleasant and unsafe. The concentrated-filament incandescent lamp which had been developed for use in headlamps furnished beam intensities far beyond those possible with the acetylene headlamps which had previously prevailed, and the conditions of glare thereby introduced constituted a menace to public safety. Efforts at regulation of headlights by the states had been made on unscientific lines and had generally proved entirely ineffective.

In 1917 the Illuminating Engineering Society proposed a laboratory test to govern the approval of headlighting devices used on automobiles and thereby introduced a system for the scientific solution of the problem. The testing rules and the specified limits which were included therein were revised in 1919, and, particularly in the revised form, they have constituted the basis for the approval of devices by a number of the largest states.

In 1920 the State of Massachusetts adopted the I. E. S. system but introduced certain changes into the regulations and candlepower limitations which went beyond those proposed by the Society. The results which accrued from the adoption of the Massachusetts figures were for the most part favorable and indicated that the I. E. S. figures could with advantage be further revised. This revision has been carried out, and it has been found that in the light of all the experience which has resulted it is possible to carry the regulations somewhat further than Massa-

chusetts had done. The rules and specifications so revised have appeared in the February issue of the Society's TRANSACTIONS. The State of Massachusetts has already adopted the revised I. E. S. specifications instead of its own. This is an important gain inasmuch as it leaves the I. E. S. specifications alone in the field as the only existing standard through which interstate uniformity in respect to this important regulatory matter can be attained.

The I. E. S. has undoubtedly performed a very important public function through its activities in this field, and the result has shown that a disinterested engineering society working on a scientific basis is more than able to justify its existence from the point of view of the unselfish services which it may render.

CLAYTON H. SHARP, *Chairman,*
Committee on Motor Vehicle Lighting.

REFLECTIONS

The Boston Convention

AFTER A PERIOD of more than ten years, it was finally unanimously decided by the Committee on Time and Place, to hold the 1922 Convention in the City of Boston during the last week of September.

Noted the entire world over as a great educational center, Boston seems an ideal place in which to hold the annual meeting of our Society, as there is no doubt in addition to the delegates who will attend the Convention from all over the Country, particularly east of the Mississippi River, we should have a large student representation from both Massachusetts Institute of Technology and Harvard University, among whose teaching staff there are scattered a number of members of our Society.

In this city about a year ago, there was organized a Bureau for Better Illumination and an exhibit has been held three or four times a week since then and to date attended by over 2000 people, in the Rogers Building of the Massachusetts Institute of Technology, so that the subject—"BETTER ILLUMINATION"—has been brought before all classes of people, including representatives of educational institutions, branches of state bodies responsible for rules and regulations governing factories in the State, heads of various lighting syndicates with headquarters in Boston, and Vice-Presidents, General Managers, and the electrical staff representing from 150 to 200 large industrial establishments scattered throughout the entire State.

Mr. Charles L. Edgar, President of the Edison Electric Illuminating Co. of Boston has accepted the Chairmanship of the General Convention Committee, and the prestige of his name should insure the active support of all affiliated interests, and thus make this Convention a banner one from the standpoint of attendance, quality of papers, character of entertainments and all other things which go to make up a successful Convention for an Engineering Society of the character of ours.

Luminaire

THE WORD "LUMINAIRE" selected from numerous suggestions submitted to the Committee on Nomenclature and Standards is proposed as the equivalent of such terms as lighting unit, candelabrum, fixture, etc., which so long have encumbered illuminating engineering literature. Upon recommendation of the Committee on Nomenclature and Standards, the Council has taken under advisement the adoption of this word for use in the

Society's TRANSACTIONS. Before deciding finally, however, the Council communicated with other engineering society and commercial organizations in whose literature terms of this kind find place, to ascertain if such bodies would be willing to join with the Illuminating Engineering Society in the adoption of luminaire. Several favorable replies have been received and in no case has the suggestion met with disapproval.

The Council adopted the use of word "Luminaire" at its meeting on March 9, 1922.

New York Has School of Lighting

UNDER THE DIRECTION of Mr. Frederick J. McGuire, of the Department of Water Supply, Gas and Electricity, New York, a course in illumination is given in schools in Manhattan and Brooklyn. The Manhattan school is located at 237 East 37th Street, where instruction is given on Monday and Wednesday evenings. In Brooklyn the course is conducted at Manual Training High School, 7th Avenue, 4th-5th Streets, on Tuesday and Thursday evenings.

Students receive instruction in various methods of illumination and also in fundamental and visual acuity tests, comparison of artificial and natural light, flux of light, quality or color of light and analysis of the design and characteristics of the various types of lighting fixtures, intensity of light versus glare, analysis of the various systems of lighting, that is; direct, semi-indirect, cove, local, combination of indirect and local lighting, etc.

The course is intended for architectural draftsmen, designers and salesmen of lighting fixtures, electricians, and those in charge of the lighting equipments of large mercantile, commercial, industrial and educational establishments, who, after a short course of instruction will be qualified to formulate or select systems of lighting that are based on the four fundamental principles cited.

Remarkable interest has been taken in the course, and the attendance is large. Young men and old men, some who already are employed in the lighting industry and those who are interested and have been attracted by its possibilities; compose the classes.

The demand for men who by virtue of their study, training and experience are qualified to give advice, or to formulate designs for efficient and economical systems of artificial illumination is not only very great and urgent, but still increasing. The demand at present and for the immediate future is, and will be, greater than the supply, due solely to the lack of practically trained men.

PAPERS

RADIOLUMINESCENCE AND ITS TECHNICAL APPLICATION*

BY VICTOR F. HESS, PH. D.**

SYNOPSIS: Radioluminescence is luminescence caused by the rays of radioactive substances. The difference between this phenomenon and the phosphorescence caused by sunlight or artificial light is pointed out by experiments. It is shown also by experiment that the penetrating rays (beta- and gamma-rays) do not give a luminosity bright enough for technical purposes. The alpha-rays of less than one-tenth of one milligram of radium or equivalent other radioactive substances produce sufficient luminosity when mixed with about one gram of zincsulfide and little "impurities" which are essential iu order to get the best effects. A description of the processes of production of "Radium luminous material" and demonstration of its technical application is given. Luminous material is especially important for the illumination of dials of watches, clocks, and all kinds of electrical and technical instruments. All other applicatious are discussed.

A computation of the economy of luminous material is given. It is shown that the ratio between the amouut of energy given off by the alpha-rays of radium mixed with each gram of zincsulfide and the intensity of light produced is 0.05-0.07 watt per candle approximately. This efficiency is about ten times the efficiency of incandescent lamps.

The absolute brightness of luminous material cannot be increased over a certain limit without diminution of the durability of the respective sample.

The process of extraction of radium and commercial manufacturing of luminous material were demonstrated by a moving picture film taken at the plant of the United States Radium Corporation in Orange, N. J.

The development of the radioactivity and the theory of relativity has shown that marvelous powers are hidden within the atoms, not only of the radioactive substances but also of all other chemical elements. When atoms undergo radioactive decay and are transformed into other ones of simpler structure certain amounts of atomic energy are freed in the form of kinetic energy of the constituents of the atom. This kinetic energy is ultimately transformed into heat and in fact it has been observed that according to this, radium produces heat continuously at the rate of 135 calories per gram per hour.

Radium is a so-called longlived product among the radioactive substances. Its transmutation is so slow that in 1580 years one half of it still remains unaltered. When we consider the amount of energy given off by one gram of radium during this period of

* A paper presented before the New York Section of the Illuminating Engineering Society, October 20, 1921.

** Chief Physicist, United States Radium Corporation, Orange, N. J.; Consulting Physicist to the U. S. Bureau of Mines.

years we deal with enormous figures. All this energy was originally hidden within the atoms and we could use it if we had the means to accelerate the transformation, but so far this has been found impossible. Using for instance one gram of radium, one has to consider that atomic energy is disposable only at a rate of 135 gram-calories per hour. Taking smaller quantities of radium the corresponding amounts of atomic energy become very minute.

Nevertheless it has been possible to use this atomic energy not only medically for destruction of living cells and so forth, but also technically for production of light.

This light or luminescence is produced when the rays of radium or other radioactive substances impinge on certain minerals or salts like willemite, zincsulfide, etc. This phenomenon is called *Radioluminescence.*

The rays of radioactive substances are called "Becquerel-rays." As is known there are three different kinds of these rays; the alpha-, beta- and gamma-rays.

Luminescence is not only created by the rays of the radioactive substances. There are a great many salts of metals which when exposed to daylight or artificial light of sufficient strength, glow brightly for a short time after exposure. Ordinary light, especially the parts of shorter wave lengths are absorbed in these "phosphorescent" salts, accumulated and transformed into light of other wave lengths, which are given off gradually, this phenomenon is called photoluminescence or phosphorescence.

Especially strong in phosphorescence are the sulfides of calcium barium, strontium and zinc. After exposing these salts to the light of an arc lamp or a bright incandescent lamp they all are shining very brightly in different colors. This is the basic phenomenon of phosphorescence. When these salts are kept in a dark room the intensity of the phosphorescent light diminishes rapidly and disappears. Technically therefore these substances can be used only a few hours after exposure to light.

Spectroscopic analysis of the phosphorescent light shows that it consists of a series of bands; for instance, zincsulfide gives bright bands in yellow and green with the maximum intensity at a wavelength of 0.55 microns.

Phosphorescence or photoluminescence and radioluminescence are entirely different processes. The latter is a luminescence caused by the alpha-, beta- or gamma-rays.

The salts of radium are all self-luminescent. The brightness decreases considerably when the surface of the salt becomes moist. Freshly molten salts of radium give a very bright bluish light, perceptible even in full daylight. It may, because of self-luminescence of radioactive salts, be expected, that radium preparation will produce luminosity also in other substances, when they are brought sufficiently near to the preparation.

The first observation in this line was made by H. Becquerel in 1899. He and later observers have shown that salts of the metals of the alkaline group and of the group of the alkaline earths, become luminescent when they are exposed to Becquerel-rays.

Some of these substances are especially sensitive against beta- and gamma-rays, while others respond only or mostly to the alpha-rays.

Among the substances which become luminescent under the influence of beta- and gamma-rays, minerals like willemite, kunzite and fluorite must be mentioned in the first line.

Willemite consists mostly of ortho-zincsilicate and gives a light green luminescence. Kunzite, a compound of the formula $LiAlSi_2O_6$ is a mineral of pink color. Exposed to beta- or gamma-rays it gives a bright phosphorescence of orange color. When this mineral is exposed several days to the rays of a strong radium preparation, its natural pink color turns to a beautiful green, fluorite or calcium fluorite gives a bluish luminescence.

It may be mentioned that materials which are used in X-ray screens, such as calcium-tungstate and barium-platino-cyanide, become luminescent also under the influence of the gamma-rays. Zincsulfide also becomes luminescent when exposed to these rays, but relatively to a much lesser degree.

It has to be emphasized that strong radium preparations (at least 50 mg. corresponding to a value of $6,000) are required in order to produce a luminescence by the effect of the beta- and gamma-rays that should become bright enough to be seen from any

point of a large auditorium. The possibility of using these effects for commercial purposes is therefore absolutely excluded.

Now the radioluminescence produced by the alpha-rays shall be considered. Professor *Giesel* was the first who found that Sidot-blend (zincsulfide) became very brightly luminescent when exposed to alpha-rays. Sir William Crookes in England and Elster and Geitel in Germany examined this phenomenon by means of microscopes and detected that the radiophosphorescence as produced by the alpha-rays is not a stationary and homogeneous glowing like that produced by the penetrating rays: on the contrary even through a magnifying glass it is seen that the light consists of an enormous number of single bright light-spots. These spots correspond to the points, where the alpha-particles impinge on the crystals of zincsulfide. Each alpha-particle causes one light-spot, or as we call it, one *scintillation*. The phenomenon of scintillation is historically interesting as the first known experimental evidence of the individual existance of atoms. With a weak source of alpha-rays it is even possible to find the number of these particles given off per unit of time by counting the scintillations on a zincsulfide screen. Thin cuts of diamonds also serve very well for this purpose. The duration of a single scintillation is extremely short and has been estimated to be about 1/40000 of a second.

When zincsulfide is exposed to very strong sources of alpha-rays for a long time the color of the salt changes to grey and the intensity of the single scintillations becomes less and less, while the total number of scintillations remains unaltered.

Now the questions arises, how has radium to be applied, in order to get the scintillation effects of the alpha-rays. It must be considered first that all alpha-particles have a certain range. In air they are not able to go farther than 1 to 3 inches before they lose their power to give scintillations. In solid bodies like glass, mica, or within salts they are stopped at a distance of about 0.04 cm. (1/60 in.).

Therefore it is necessary to bring the zincsulfide very near to the radium salt or better still to mix small amounts of radium salts with the zincsulfide. Mixtures of this kind are called "*Luminous Material.*"

Luminous material is a very good means for using the atomic energy of the radioactive decay or in other words the kinetic energy of the alpha-particles for production of light. An amount less than 1/10 of a milligram of radium mixed with one gram of zincsulfide gives sufficient brightness for all purposes in which luminous paints are used.

It can be easily shown that the luminescence given by such material containing about 1/100 mg. of radium is greater than the luminescence which is produced by the beta- and gamma-rays of a tube with 50 mg. of radium.

Luminous material can be applied on the surface of bodies which are to be illuminated in different ways; either it is mixed with a volatile liquid and then used like a paint or it is mixed with a transparent lacquer; or distributed in powdered form in grooves, depressions or holes on the surface of the body which is to be illuminated. In the latter case it is necessary to protect the luminous surface by glass or other transparent coverings or by a coating of good lacquer. Against the normal phosphorescent substances which were demonstrated at the beginning of this lecture, the radioactive luminous material shows a very marked difference: "Radium Luminous Material" keeps its luminosity for years without any supply of energy, while phosphorescent paints and salts glow for only a couple of hours after exposure to strong light.

Another difference exists in its sensitivity to red light. The normal phosphorescence can be extinguished artificially by exposing the salt or paint to red light. On the other hand, radioactive luminous material is not affected by red light at all.

It may be of interest to say something about the processes used to prepare luminous material. There are different methods, the details of which are kept secret by the inventors or firms which produce the material. In principle the procedure is the following: zincsulfide of very fine crystalline structure is mixed with a solution which contains radium chloride or bromide, with little impurities. Afterwards the zincsulfide is dried at slightly increased temperature. Too much heat or crushing the crystals diminishes the luminosity.

In order to get the maximum of brightness it is necessary to accumulate the emanation and all other successive products of the radium family within the radium-zincsulfide mixture. This is done either by covering the active layer with glass or other transparent material, or by mixing the luminous material with an adhesive which after drying keeps the salt tightly closed.

It must be stated, however,, that the durability of all luminous material is not infinite. Radium itself, which is mixed with zincsulfide decays very slowly: it comes down to half its amount in 1580 years. With a year it diminishes therefore only 0.04 per cent. The diminution of the luminosity of luminous material is therefore not due to the normal radioactive decay, but to a deterioration of the zincsulfide, which is caused by the innumerable impacts of the alpha-particles on the crystals. The more alpha-particles impinge per second, the quicker the salt becomes tired as one might say.

For that reason there is an upper limit of the percentage of radium in luminous material: commercially are produced only those grades of luminous material which give good luminosity for at least five years.

Immediately after the mixture is prepared the luminosity increases according to the accumulation of emanation and its successive products for about four weeks. When the equilibrium has been reached, the luminosity has been found as being proportional to the amount of radium present per gram of zincsulfide.

Different practical cases require different grades of luminous material: for instance, when a large surface is to be painted, it is sufficient to take a very low grade, not only from the standpoint of lower costs. Very thin layers of luminous material do not give the full effect; it is necessary therefore to use thicknesses of about 1/50 of an inch, in order to obtain the maximum brightness characteristic to each specific grade.

Luminous material may be applied practically at any place where a source of light is required without any supply of external energy. The great advantage of luminous material as compared to phosphorescent paints lies in the fact that luminous material is always ready for use, no prior exposure to light being necessary.

The technical and commercial use of luminous material is so manifold that it is hardly possible to go into details. In many cases luminous coatings are used for locating objects, in other cases figures and pointers or letters are to be illuminated so that they may become legible or distinct in the dark.

Among the numerous possibilities of application of luminous material the following may be mentioned:

Watches and clocks: The figures and corresponding points of the dials are illuminated by coating with luminous material. The hands are coated in the same way.

Dials and pointers of scientific and technical instruments: such as aneroids for airplanes, compasses for sport and navigation, automobile and motorcycle speedometers, gasoline gauges, steam and pressure gauges.

All kinds of electric switch buttons like: Push buttons, flip switches, bell pushes, electric pull-chain pendants, hospital call-bells.

Other applications: House numbers, locks, motor screws, safe combinations, revolver and gun sights, telephone mouthpieces, fire extinguishers, buttons for bedroom slippers, fish baits, theatre seat numbers, Pullman numbers, poison indication labels for house-dispensary.

Luminous material is also very useful for military purposes. During the European war large amounts of radioactive substances in luminous material were consumed.

From the standpoint of the illuminating engineer it is of interest to consider the light economy of luminous material; that means the relation between the energy given off the radium which is mixed with each gram of zincsulfide and the brightness which is produced by it.

British and German authors report that a quantity of 0.1 milligram of radium mixed with one g. of zincsulfide should give a luminous surface of 1.5 square inches with a brightness equal to that produced by a lamp of 10 candlepower at a distance of 10 meters or about 30 feet. The specific brightness of the luminous area is therefore 10 microlamberts and the sum total of light given off by the whole surface 0.0001 mean spherical candles.

The amount of energy which is given off by the alpha-particles when they are stopped in the layer of luminous material can be

derived easily from the production of heat of the radium. It has been found that the alpha-particles of one gram of radium alone produce 124 gram-calories per hour (St. Meyer and V. F. Hess). One-tenth mg. of radium gives therefore 0.00000348 calories per second or 144 erg per sec. This is equal to 0.0000144 watt.

The amount of energy of the alpha-particles in luminous material to produce light of the intensity of one normal candle therefor is $\frac{0.0000144}{0.0001} = 0.144$ watt per candle. The modern metal-filament bulbs consume about four times as much.

The calculated example gives a very low value for the specific brightness. Luminous material as manufactured in this country gives a specific consumption of 0.05-0.07 watt per candle, which is certainly a very good efficiency compared with that of the electric light or even the arc-lamp.

DISCUSSION

The papers by Messrs. Hess and Mathews were discussed together. See page 144.

FLASHLIGHTS AND FLASHLIGHT BATTERIES*

BY EUGENE H. MATHEWS**

SYNOPSIS: The development of the flashlight since first manufactured twenty years ago is discussed. A description of the first miniature lamps made with carbon filaments and details of battery construction are mentioned. Four classes of flashlights are in use to-day, and the development of the spotlight type is treated in length. Two factors made possible the economical use of the flashlight, first the introduction of the tungsten filament lamp in 1907 and second, the final development of a flashlight battery cell which increased the cell capacity by five hundred per cent of the earlier types.

Some statistics are presented showing the comparison of flashlight and flashligh battery sales for last year with other standard electrical appliances and specialties. Mention is made of the universal use of the flashlight in various forms.

The first flashlights were manufactured in this country twenty years ago and were exhibited at the first Electrical Show held in Madison Square Garden, New York City. The booth in which they were displayed was decorated with paper flowers and bowls of goldfish were placed in the several corners of the enclosure. Flashlight lamps were distributed throughout the flower decorations and flashed in behind the glass bowls. The whole exhibit was novel and in decided contrast with the other booths where only large electrical machinery such as motors, generators, switchboards, etc., were on exhibition. Thousands of people were attracted only by the decorations and after examining the flashlights they all invariably asked the same question. Apparently no one at that time could visualize the future possibilities for the flashlight. It required courage and fortitude, after exhibiting the invention and failing utterly to convince anyone that the light was practical, to continue the development work with the investment of more time and money in a project which, if judged by the attitude of the public, apparently had so few possibilities.

The flashlight is an American product and was invented by Mr. David Misell. The first model was a very crude affair and consisted only of a paper tube with metal fittings, a rough brass stamping used for reflector without any lens, and a spring contact switch. The lamp was hand made, as was also the battery. It was submitted in this form to the first manufacturer of flash-

* A paper presented before the New York Section of the Illuminating Engineering Society, October [illegible]

** American Eveready Works of National Carbon Co., Inc., Long Island City, N. Y.

lights in 1898. Probably the idea originated from the fact that, if current could be supplied from the ordinary six inch cell for bell-ringing circuits and for supplying energy, where the demand for current was not too high, that it might be possible to construct even a smaller cell and assemble two or three of these in series, thus obtaining sufficiently high voltage for the illumination of a small lamp. This idea was followed out, and the cells of the first battery were constructed in miniature very similar to the large six inch battery manufactured at that time.

The flashlight as a whole is composed of three units; the case, the lamp, and the battery. The case is the container for the battery and supports the reflector and lamp, it carries the switch and becomes a part of the circuit. There have been very many different types of circuit arrangements and a great number of different kinds of switches. Reflectors have been made with many different surfaces and contours.

During the time while the battery was being developed, lamp manufacturers were asked to consider the manufacture of the small miniature lamps necessary for use with the flashlight. When consulted regarding the construction of a lamp which could be made to operate at 3.8 volts, they immediately stated that it would be impossible. It was their opinion at that time, that a 4.5 volt lamp could possibly be made, but they were positive that the flashlight would never be a success, and, therefore, could not be induced by any arrangement whatever to take up the manufacture of the lamp. As the public had evinced no interest whatever in the flashlight as a useful tool and having been definitely informed by the engineers of the largest manufacturer of incandescent lamps that the idea was impractical, the manufacturer himself very nearly lost faith in the invention as a commercial product. With no knowledge of the art of lamp manufacture, but with full realization of the difficulties ahead, a small shop was established in Providence, R. I., where flashlight lamps were first manufactured. The force consisted of one individual and it was his practice to manufacture a few lamps at a time, and deliver these in New York personally. Very shortly the force was increased and miniature lamps were provided in sufficient quantities to meet the growing demand. Later on, a company was

incorporated and established in New York, and this company existed until the demand became so great that the lamp manufacturer, who a few years before had refused to consider the miniature lamp as a practical product, was very glad to take over the manufacture of flashlight lamps.

It might be interesting to note here that miniature lamp manufacture, that is, the manufacture of flashlight and automobile lamps, has reached the point where if the increase continues as at present, the number of miniature lamps manufactured will in 1928 equal the production for all standard incandescent lamps.

A carbon filament was used in the first lamps. This filament operated at from three to four watts per horizontal candlepower and naturally for flashlight service was extremely inefficient. Coupled with a dry battery, which provided only about one-sixth of the service of the present flashlight battery, it may be readily understood why the flashlight remained so long in the novelty class. Two factors finally made possible the economical use of the flashlight as a staple lighting agent: First, the development of the tungsten filament lamps in 1907 increased the lamp efficiency from three to four watts per horizontal candlepower to approximately one and one-quarter watts per horizontal candlepower; the other factor was the final development of a flashlight battery cell which increased the cell capacity about 500 per cent over that of the earlier cells manufactured.

Unfortunately, there is no data as far back as 1901 which would show the "intermittent" tests as compared with the "continuous" service tests. The continuous test is simply a discharge test of the battery made through resistance which corresponds to the average lamp resistance. The resistance used is $2\frac{3}{4}$ ohms per cell. The cells are discharged through this resistance and when the difference of potential at the terminals of the cell has finally dropped to 0.5 volt, it is considered exhausted. The No. 705 battery, at the present time, can be discharged on continuous service for approximately 550 minutes before it reaches a state of exhaustion beyond which it would not supply energy for satisfactory illumination. If after being exhausted on continuous service the battery is allowed to stand for several hours, it will

recuperate sufficiently to give about 250 minutes additional service.

The dry cell is a perishable product. Just as soon as the cell is manufactured deterioration starts on open circuit and the efficiency of the cell is effected by this deterioration. It has not only been a problem of increasing the life and service on closed circuit, but also decreasing the deterioration on open circuit when the cell is standing and idle, that is, the electro-chemical problem is to combine the materials of the solution in such proportions that the action will, on closed circuit, be energetic and, at the same time, to provide for and maintain the cell in an inert condition on open circuit. The results obtained up to the present time have only been accomplished after diligent laboratory research followed by exacting laboratory control of the manufactured product.

The flashlight battery which is most generally used to-day, will only depreciate about 35 per cent in 12 months on open circuit. As a result of this improved service, the value of the flashlight has been greatly increased in those localities where a light is most necessary and where heretofore, due to the depreciation of the battery, it was impossible to obtain such a battery in satisfactory condition. I refer principally to the use of flashlights in the Tropics and in the Far North where it is now performing invaluable service.

The dry battery is composed of three essential parts: the zinc cup, the electrolyte, and the bobbin. The service of the battery is dependent upon the depolarizing action of the bobbin. The bobbin is composed of a mixture of manganese dioxide and graphite in certain proportions and formed about a carbon electrode. The bobbin is wrapped in cotton gauze and is then placed in a cup of pure metallic zinc. Electrolytic paste, consisting of ammonium chloride and zinc chloride mixed together with proportionate amounts of flour and water constitute the electrolyte.

Flashlights, as manufactured to-day, may be classified into four particular kinds of service:

The first class, that of the tubular flashlight which is adapted for use indoors and is capable of illuminating objects within a radius of twenty to thirty feet.

The second class, is the lantern type light which is not exactly a flashlight as it is more generally used as a continuous burning light. This type is employed generally as a safety lamp about the camp and in the home. Some people, however, prefer the lantern type light for general use as a flashlight, as it is convenient to carry with the handle and may be placed easily in any position. It is a light which is well adapted for use where a kerosene or open flame light would be dangerous.

The third class constitutes the small flat vest pocket light. This flashlight is simply a case constructed to contain the battery and to support a flat end miniature lamp, no reflector is provided with the light and its use is confined entirely to the illumination of objects at very short distances. Portability is the feature of this type, as it may be carried on the person with no inconvenience.

The fourth and newest class is the spotlight type or projection light. This flashlight has just been placed on the market. It is well adapted for use out-of-doors. The projection is such that objects may be illuminated at a distance of 300 feet. Large objects, such as, houses, tents, etc., may be illuminated at distances of 1,000 feet. The light is equipped with a parabolic reflector and a special type lamp. It should be noted that the focusing is accomplished by means of the end cap which may be turned to the right or to the left. There is provided in the end cap a container into which are placed two extra lamps, in order that renewal lamps may be immediately available. As this light is designed for use by motorists, campers, vacationists, police officers, firemen, watchmen, and for industrial uses, it is essential that extra lamps be available.

In years past, practically no attempt was made to design a flashlight which would produce a certain pre-determined projection. Most of the earlier lights and in fact a great many of the modern lights of to-day are equipped with thick heavy plano convex lenses. This particular type of moulded lens, which has been used on most flashlights, is probably an outgrowth of the old Bull's Eye Lantern lens. It is somewhat deceiving to the laymen as it creates the impression that the magnification increases the amount of light projected. Probably the real reason for the use of the plano convex lens is for the mechanical

strength obtained with this form. In all cases the plano convex lens has been used in conjunction with a reflector approaching the curvature of the paraboloid. The proper optical system would be a spherical mirror with the source of light at the center of curvature, and a lens used in conjunction with this mirror, to refract the rays in parallel lines. The focal distances necessary with an optical system of this character are of such great length that it precludes such a system for use with the flashlight. Due to the fact that no means whatever had been provided to place the source of light at the focus of the reflector, the character of projection obtained with the combination of parabolic reflector and plano convex lens is anything but satisfactory. In some very rare instances, the errors would be such that accidents would happen and a fairly good projection would be obtained, that is, the light source would be forward or back of the focus, and the lens would refract the resultant rays in such a manner as to rectify the errors due to the incorrect position of the filament. It is impossible to obtain the same character of light projection even with identical flashlight reflectors, due to the fact that the light center distance of flashlight lamps have a maximum variation of 3 millimeters. Therefore, unless some form of focusing arrangement is used, it is very probable that the filament will be incorrectly positioned in relation to the focus of the reflector.

After conducting a number of experiments with the regulation flashlight reflectors and lamps, it was finally assumed that if small reflecting surfaces could be made which would conform fairly well with the surface of the paraboloid, if a lamp could be manufactured which would have a very small concentrated filament, and if a means could be provided to move the lamp along the axis of the reflector so that it could be placed at will at the focus of the reflector, it would then be possible to produce a beam of light which would far surpass the projection which had heretofore been obtained with the flashlight.

The function of the parabolic reflector is to reflect light rays eminating from a small source, located at the focus of the reflector in parallel lines. Due to the fact that the light source cannot be made a mathematical point, the rays can never be absolutely parallel and there will always be a slight spread to the beam.

The dimensions, that is, the diameter and the depth of the reflector determine to a great extent the intensity and the character of the ultimate projection which will be produced. The diameter of the reflector is limited by the present types of flashlights which are now manufactured and further, it would, for practical use be unwise to attempt to increase the size of the flashlight head.

In order to determine the proper depth for the parabolic reflector for the spotlight flashlight, it was necessary to spin reflectors having different depths and ascertain by experiment the correct depth for a pre-determined diameter which would yield the highest beam candlepower. The diameters of these reflectors were all the same dimension and the depths varied from 1 inch to 2½ inches in steps of ¼ inch. In each instance the same lamp was used for each reflector and was operated at constant voltage throughout the photometric tests which were made with the Macbeth Illuminometer. The reflector having a depth of 1¼ inches proved to be the most efficient. The maximum beam candlepower obtained with this reflector was 3,000 and the total spread of the beam was about six degrees.

After making the above experiments a flashlight was assembled, equipped with the parabolic reflector and the specially designed concentrated filament lamp. Trials were made at night when there was no moonlight to interfere with the observations. At a distance of 70 feet house numbers 3½ inches in height were easily read; at a distance of 300 feet an individual could be distinguished either against a dark or a light background; at a distance of 700 feet or over, buildings, houses, etc., and objects having light colored surfaces were illuminated so that it was possible to note all details, such as cornices, windows, gables, and chimneys.

Considerable difficulty was experienced by lamp manufacturers in producing the specially designed lamp which is now used in this particular light. The lamp finally adopted has a coiled tungsten filament of approximately thirty coils so fashioned that the filament is in the form of a "U" and occupies a very small space. The brilliancy of this light is very high. It operates at 3.8 volts and its life is designed for approximately 24 hours,

in fact it has the same electrical characteristics as the regular 3.8 volt flashlight lamp. A very interesting paper could be written on the subject of the development and manufacture of this particular flashlight lamp. Some of the gentlemen who are responsible for its development are members of this Society and to them a great deal of credit is due, for the conscientious work performed in making possible a satisfactory lamp for this particular and exacting service.

Considerable time had elapsed after both the lamp and reflector had been developed before a suitable adjusting or focusing arrangement was devised. Any number of different mechanisms were suggested and models were made, and finally a satisfactory mechanism was developed, patents applied for and tools designed for the manufacture of the several parts. When the end cap of the flashlight is turned to the right, the contact member in the end cap moves forward and engages with the battery, driving the battery forward. This forward motion is transmitted to the lamp socket and a positive contact is assured by the compression taken up on the spring. In this manner the position of the lamp may be adjusted so that it will coincide with the focal center of the reflector.

It would be of interest to mention some of the general facts regarding the flashlight. Someone has said that an idea which is not a practical and commercial money-maker, is not a practical idea; the flashlight idea was born of a demand for a safe, portable, self-contained electric light.

You will, perhaps, be interested to know in what relation the flashlight industry stands, with some of the other commercial successes of the electrical industry You have seen electric toasters advertised and widely displayed in dealers' windows. The yearly volume of this business is at retail list, $2,400,000. Electric bells, push buttons, annunciators, etc., a well established line, totals approximately $5,000,000 business per year. The largest electrical specialty on the market is the electric fan, which sells at an average price many times that of the flashlight; the total volume is about $25,000,000 per year. The electric flat-iron is another big item which totals $17,500,000. Other miscellaneous

electrical appliances, such as curling irons, and special heaters, have a volume of $3,000,000 per year.

As compared to these several electrical specialties the flashlight and battery sales amounted last year to over $20,000,000, this is on a product selling at an average retail list price of from $1.50 to $2.00 for the flashlight, and between thirty-five and fifty cents for the battery. These figures were compiled by and obtained from one of our leading electrical publications and are vouched for as accurate. It is also stated that there are more than 10,000,000 active users of flashlights in the United States, or practically one person in every ten owns or uses a flashlight. More than 5,000,000 flashlights are sold annually and more than 25,000,000 batteries are required annually to take care of the flashlights already in use and for the growing demand.

During the twenty years that have elapsed since the first flashlight was produced, there have been over 580 patents allowed covering flashlights, hand lamps, and combinations involving flashlights. Thousands of uses have been discovered, all within the three broad groups of utility, convenience and protection. While the flashlight is a lighting agent which is used for any number of different purposes and under a great variety of conditions, it should never be forgotten that as a light to be used as an emergency, it has no other illuminating competitor. There is a big field for emergency work. The time is coming when it will become standard equipment, recognized as such by the Board of Fire Underwriters and endorsed by all Safety First organizations. The flashlight will soon take its place with the fire extinguisher as standard emergency equipment on steamers, railroad trains, theatres, hotels and for all public buildings.

There are on record a great many interesting and dramatic incidents where the flashlight has played an important part. The flashlight was with Perry when he discovered the North Pole, and was carried by Roosevelt in the jungles of Africa and South America. It crossed the Atlantic with the American seaplane NC—4 and was carried by Brown and Alcock on the first airplane trip across the Atlantic. It has been used in many cases for signalling on land and sea, and its use was very valuable in many ways in the World War. Thousands of people are now

using the flashlight in their homes and about their business for every purpose where it is necessary to have illumination.

No other line of electrical development is receiving more concentrated effort for efficient development and manufacture. Flashlights and flashlight batteries are highly technical products and can only attain their greatest usefulness by scientific research and experiment. It has been said that all men and their institutions are measured only by service. Surely, then, the electric flashlight should rank with other necessary commercial necessities which are contributing to our convenience, our safety and our happiness.

DISCUSSION

J. B. Ewart: I would like to ask if the manufacturers of radio-luminous materials and the manufacturers of flashlights have yet co-operated to the extent that we have a flashlight that we can find in the dark?

V. F. Hess: About the cost of those buttons, Mr. Dey, who is head of our computation department, would be able to give you computations.

W. H. Dey: The cost of those would vary considerably with the treatment. I have been doing quite a bit of research work in the last few months in connection with that and we are now ready to demonstrate to the flashlight manufacturers, and arrangements have been made to show them a new method which will reduce the previous cost and at the same time give greater efficiency. I believe the luminous flashlight is a very near possibility.

Chairman Bozell: Is there any further discussion or are there any questions? If not, I take it that both Dr. Hess and Mr. Mathews will be willing and glad to show, upon personal examination, the various exhibits they have brought.

Non-Member: The last speaker said that some of these lights had been taken to the North Pole. What temperature do you have to reach before the dry cell will go out of commission? I think it will not last very long.

E. H. Mathews: Attempts have been made to utilize luminescent material on flashlights in order that they may be readily seen in the dark. Luminescent material is expensive, however, and as flashlights are sold at a very low price, the addition of the expensive luminescent material makes quite a difference in the selling price of a flashlight. We have considered, and have had models made up with luminescent material in the form of buttons, and placed on the flashlight, but we did not feel that it could be put on the market without raising the price. However, if other manufacturers of flashlights were to adopt luminescent material, we I think, would also be glad to consider using this material.

We have never made any extensive tests on flashlight cells at extremely low temperatures. The service of a flashlight battery is very slightly affected when operating at 32° F. and is only about 15 per cent lower than the service obtained at normal temperatures. However, at -15° F. the flashlight cell will operate for approximately 15 minutes on continuous service as compared to 500 minutes at normal temperatures. Where flashlight batteries have been supplied to expeditions going into the Polar regions we have advised that, in order to obtain satisfactory service, or, in fact, any service, it would be necessary to carry the flashlight close to the body in order to maintain the battery at satisfactory operating temperatures; or in the event where batteries had been exposed to extreme low temperature conditions, that the temperature of the battery be raised before putting the cells into service.

E. C. Crittenden: We have had occasion to test some dry cells for one of the arctic expeditions in order to determine whether the cells would serve to operate certain equipment at very low temperatures. It was found that as the temperature is lowered the voltage of the cells drops only very little. The current obtainable from the cells, however, decreases considerably, and the output of the cells is therefore also materially decreased.

L. C. Porter (Communicated): Mr. Mathews, in his very interesting paper, has pointed out the remarkable growth of

flashlights for general lighting purposes and also for signal work. In addition to these services, flashlights have recently been used for the projection of pictures.

There has just been placed on the market a standard flashlight battery and casing fitted with a specially designed reflector in the shape of an ellipsoid. In front of this reflector is placed a lantern slide, mirror and an objective lens. The slides used in this little device consist of individual "positives" cut from motion picture films. On a white wall or a sheet, very good pictures 4 feet wide can be obtained in a dark room, and on a prepared screen, pictures as large as 10 feet are possible. This is a remarkable performance from a small 3.8 volt, 0.3 ampere, flashlight lamp. The outfit is sold both as a toy and for purposes of giving lectures to small audiences, doing away with the necessity of carrying the usual heavy stereopticon lantern, glass slides.

SOCIETY AFFAIRS

SECTION ACTIVITIES

NEW ENGLAND

Meeting—February, 1922.

A most successful meeting of the New England Section was held at the Engineers' Club on Monday, February 27, 1922, at which representatives of Prizma, Inc., presented papers and a demonstration of colored motion pictures. The subjects and speakers were as follows: "Making Natural Color Motion Pictures" by Mr. William V. D. Kelley, "With Prizma in Africa" by Mr. William T. Crespinel, and "The Psychology of Color as Applied to Motion Picture Drama" by Mr. Carroll H. Dunning. The talk which was probably of most value to the Society was that of Mr. Dunning.

The meeting was attended by about sixty-five persons, including ladies, and while there was not much discussion, due to the long program, the general concensus of opinion was that it was a very successful evening.

CHICAGO

Meeting—February, 1922.

At the meeting of the Chicago Section held in the rooms of the Western Society of Engineers on the evening of February 23rd, Mr. Ernest Lunn, Electrical Engineer of the Pullman Company, presented a paper "The Pullman System of Railway Car Lighting, Current Generation and Control."

Mr. Lunn gave a very interesting talk, with a panel board demonstration of the system of control for lighting and battery charging, and described the automatic method of regulating lamp voltage. He discussed the new lighting system in Pullman cars, mentioning the latest center deck fixture consisting of ceiling pan and twelve inch diffusing glass globe equipped with 100-watt gas-filled lamp, the power consumption being about 2 watts per square foot of car space, giving about 7 foot-candles when the line voltage is equal to that of the lamps.

Mr. E. D. Tillson displayed a model of a car roof complete with advertising cards which are usually seen on suburban or street railway service. There were mounted also some incandescent lamps, burning at low voltage, and glass fixtures to represent the average gas burner which is in use on some of the cars. By removing the dark green lining on the deck of the car he clearly demonstrated the value of a white ceiling. The very unsatisfactory glare which is caused by a string of bare lamps in the usual deck rail line was shown and Mr. Tillson displayed some shields to slip over the lamps which completely eliminated the glare and at the same time allowed plenty of illumination on the advertisements and points on the working plane.

A very interesting discussion was held and the meeting proved to be one of the most successful and enthusiastic gatherings of the year. A great many railway electrical engineers were present making a total attendance of fifty-four members and guests.

TORONTO

Meeting—February, 1922.

The Toronto Chapter met on February 20, 1922, at the Mossop Hotel for a luncheon; the feature of entertainment was the I. E. S. lecture on "Home Lighting" as presented by Mr. M. B. Hastings, who made use of the lantern slides and material as prepared by the I. E. S.

The lecture was well received and there were in attendance twenty-seven members and eleven guests.

CLEVELAND

Meeting—March, 1922.

At the meeting of the Cleveland Chapter held on March 15, Mr. C. A. Atherton, of the National Lamp Works, spoke on the subject, "Better Signs." The large field for improvement in signs so as to make them more effective as an advertising medium was mentioned as well as the fact that this branch of illuminating engineering has been established on a firm engineering basis. The paper brought out the fundamental principles of sign lighting and statistical data pertaining to signs in Cleveland and other cities.

An interesting discussion followed the paper and the meeting was attended by twenty-five members and guests.

COUNCIL NOTES

ITEMS OF INTEREST

At the meeting of the Council on March 9, 1922, the following were elected to membership:

Three Members.

W. E. Richards,
Superintendent, Electric Department,
Toledo Edison Company,
Toledo, Ohio.

Joseph E. Shaw,
Manager, Fixture and Illumination Department,
Frank H. Stewart Electric Co.,
37 North Seventh Street,
Philadelphia, Pa.

Albert F. Stoll,
President,
Russell and Stoll Company,
17-27 Vandewater Street,
New York, N. Y.

Thirteen Associate Members.

Carlyle Adams Atherton,
Engineering Department,
National Lamp Works of G. E. Co.,
Nela Park,
Cleveland, Ohio.

Chenery C. Bartlett,
Electrical Engineer,
The Southern Sierras Power Co.,
Riverside, California.

Robert T. Battle,
Electrical Contractor,
220 West 42nd Street,
New York, N. Y.

John J. Collins,
Electrical Contractor,
Meeks-Collins Electric Company,
411 Granby Street,
Norfolk, Virginia.

WILBUR N. COMLEY,
Electrician,
Philadelphia Stock Exchange Bldg.,
1411 Walnut Street,
Philadelphia, Pa.

WILLIAM H. EVANS,
Publicity Department,
The Philadelphia Electric Company,
1000 Chestnut Street,
Philadelphia, Pa.

WM. A. FOGLER,
Laboratories Superintendent,
Philadelphia Electric Company,
2301 Market Street,
Philadelphia, Pa.

RANDOLPH A. GAREL,
Electrician,
American Electric Cutting Machine Company,
151 Lafayette Street,
New York, N. Y.

WALTER E. L. IRWIN,
Cadet Engineer,
United Gas Improvement Co.,
1931 South 9th Street,
Philadelphia, Pa.

ROBERT M. MARLEY,
Marley Electric Company,
116 North Camac Street,
Philadelphia, Pa.

JAMES MADISON SHUTE,
Lighting Service Department,
Edison Lamp Works of General Electric Company,
Harrison, N. J.

HELEN A. SMITH,
Engineer in Lighting Service Dept.,
Edison Lamp Works of General Electric Company,
Harrison, N. J.

H. G. SMITH,
Assistant Sales Manager,
Matthews Electric Supply Co.,
1823 First Avenue,
Birmingham, Alabama.

One Transfer to Full Membership.

FRANK R. BARNITZ,
Asst. Sec'y and Gen. Supt., Commercial Department,
Consolidated Gas Company of New York,
130 East 15th Street,
New York, N. Y.

One Sustaining Member.

NARRAGANSETT ELECTRIC LIGHTING CO.,
Turks Head Building,
Providence, Rhode Island.

CONFIRMATION OF APPOINTMENTS

The appointments of the following chairman and committee members were confirmed:

As Members of the Motor Vehicle Lighting Committee

F. C. Caldwell
A. W. Devine

As Members of the Committee on Membership

H. E. Hobson
C. M. Masson

As Members of the General Convention Committee

S. E. Doane
Clarence L. Law
P. S. Millar
G. B. Regar

Chairman of the Committee on Nomenclature and Standards

Clayton H. Sharp

Secretary of the Committee on Nomenclature and Standards

E. C. Crittenden

COMMITTEE REPORTS

Progress reports were presented from the following: Committee on Sky Brightness, Committee on Bulletin on Residence Lighting by Electricity, Committee on Artistic Treatment of Interior Lighting, Committee on Editing and Publication, Committee on New Sections and Chapters.

COMMITTEE ON NOMENCLATURE AND STANDARDS.—Dr. C. H. Sharp, Chairman, reported that the Rules of 1918 have been given to the American Engineering Standards Committee to be adopted as an American Standard.

COMMITTEE ON MOTOR VEHICLE LIGHTING.—Dr. C. H. Sharp, Chairman, reported that the Committee had effected a revision of the Rules for Laboratory Headlighting Tests, a representative from the State of Massachusetts being present. Massachusetts has adopted our revised rules, so there is only one standard. These revised rules have been submitted to the American Engineering Standards Committee as a tentative American Standard.

COMMITTEE ON MEMBERSHIP.—Mr. G. B. Regar, Chairman, gave a progress report of the work of his committee and advised that while the immediate results of the campaign had not been all that the committee could have wished, it is hoped that the next few weeks would show a marked increase in our membership. Twenty thousand circulars setting forth the advantages of becoming a member of the Illuminating Engineering Society are being sent out with their bulletins, by the Westinghouse, Edison and National Lamp Works.

COMMUNICATION FROM AMERICAN ACADEMY OF POLITICAL AND SOCIAL SCIENCE. —A letter was read from the President of the American Academy of Political and Social Science, inviting the Society to appoint three delegates to attend its 26th Annual Meeting to be held in Philadelphia, May 12th and 13th. Messrs. Crampton, Forstall and Regar were appointed to serve in this capacity.

ADOPTION OF TERM "LUMINAIRE."—The Council moved to adopt the term "Luminaire" as recommended by the Committee on Nomenclature and Standards in the report presented at the annual convention in Rochester, N. Y., last September.

CONFIRMATION OF THE EXECUTIVE COMMITTEE'S APPROVAL TO REQUEST THE AMERICAN ENGINEERING STANDARDS COMMITTEE TO CALL A CONFERENCE ON THE SUBJECT OF COLORS FOR TRAFFIC SIGNALS.—The Council moved that the action of the Executive Committee be confirmed.

NEWS ITEMS.

CONTRIBUTIONS FOR THE 1922 CONVENTION

The Papers Committee is endeavoring to formulate a program for the 1922 Convention which will best serve the membership at large. In other words, it believes that without detracting from the scientific value of the papers, material can be made available of widespread or popular interest.

It is a recognized fact that a large percentage of our membership are much more interested in what may be termed "applied illuminating engineering" than in abstract discussions or theoretical subjects. Papers dealing with practice with the "how" as well as the "why" of the subject brought forth are of direct benefit. The Committee will endeavor to secure as many of such presentations as possible.

On the other hand, this policy will not reduce the number of strictly scientific papers which are of much importance in the development of the art and of great interest to certain classes of our members.

Even the most technical paper contains information of service to the man in the field if he knew how to "dig this out." The plan is to have every paper presented in such a manner that these vital facts are brought to the surface or to have some one conversant with the subject, in discussion point out how the data can be applied commercially.

The aim will be to make the Convention papers of interest to the rank and file—so valuable that no one actively engaged in lighting can afford to miss the Convention or not attend the sessions.

The Vice-Chairman of the Papers Committee, Mr. A. L. Powell, Fifth and Sussex Streets, Harrison, N. J., will welcome suggestions from the membership on suitable and timely topics and wishes to hear from members who are in a position to contribute papers which will fit in with a general scheme as outlined. The character of material desired is set forth very clearly in the Society's Manual for Authors. With the co-operation of our membership, we should be able to carry out some such scheme and assist in establishing widespread interest in the Society and the principles for which it stands.

GENERAL OFFICE NOTES

Reprints of the "Code of Lighting School Buildings" as issued in 1918 can be obtained from the general office. Price 25 cents per copy, discounts will be allowed for orders greater than fifty copies upon application.

Reprints of the "Code of Lighting, Factories, Mills and other Work Places" as published in the November 20th issue can be obtained from the General Office. There has been incorporated in the pamphlet a table of contents and an index. Price 25 cents per copy.

The following discounts will be allowed on orders in quantity:

50 copies, discount of 10% per copy.
100 copies, discount of 20% per copy.
200 copies, discount of 30% per copy.
500 copies, discount of 35% per copy.
1,000 copies, discount of 40% per copy.
2,500 copies, discount of 45% per copy.
5,000 copies, discount of 50% per copy.

Copies of the following issues are desired:

Vol. XIV, No. 9, Dec. 30, 1919.
Vol. XV, No. 7, Oct. 10, 1920.
Vol. XVI, No. 3, April 30, 1921.

The General Office will pay fifty cents each for copies in good condition of these issues.

A CORRECTION

The General Office was advised erroneously that the National Council of Lighting Fixture Manufacturers recommended the adoption of the term "Luminaire" at the Milwaukee Fixture Market. Through this misunderstanding there was printed on page 116 of the February TRANSACTIONS a note which was incorrect in substance.

PERSONALS

Mr. William T. Blackwell has resigned as Manager of the Lighting Service Department, Westinghouse Lamp Company to become Manager of the Interior Lighting Division, Westinghouse Elec. & Mfg. Co., George Cutter Works, with headquarters at South Bend, Indiana. Mr. Blackwell has been active in the illumination field for the past fifteen years. For several years he was an engineer in the Construction Department of the New York Telephone Company. In 1905 he became Assistant Superintendent of the Distribution Department of the East River Gas Company of Long Island City.

In the fall of 1907 he was appointed Assistant to the Chief Engineer of Light and Power, Bureau of Gas and Electricity, Department of Water Supply, Gas and Electricity, New York City. In May, 1916, he accepted the position of Sales Engineer in the eastern office of the Benjamin Elec. & Mfg. Co., leaving in 1918 to become Assistant Commercial Engineer of the Westinghouse Lamp Company. On Jan. 1st., 1922 the Lighting Service Dept., was organized with Mr. Blackwell as Manager. He has been active on various committees of the Illuminating Engineering Society and National Electric Light Association. In addition he has contributed many articles to the technical and trade press.

Mr. John W. Lieb, Vice-President of the New York Edison Company leaves this month for three months' trip in Europe. He will tour Italy, Switzerland, France, Germany, Holland, and England, spending most of the time visiting old friends and business associates in Italy, where he was chief engineer and technical director of the Italian Edison Company from 1882 to 1894. While in Italy Mr. Lieb will convey the felicitations of the American Institute of Electrical Engineers to its sister society, the Associazione Elettrotecnia Italiana, on the twenty-fifth anniversary of its organization, which it celebrates this year. In Rome he will present the certificate of honorary membership in the American Society of Mechanical Engineers which was recently conferred on Gr. Uff Pio Perrone.

Mr. Lieb is a past-president of the A. I. E. E., and has also been president of the Association of Edison Illuminating Companies, the Edison Pioneers, the National Electric Light Association, and the New York Electrical Society.

ILLUMINATION INDEX

PREPARED BY THE COMMITTEE ON PROGRESS

An index of reference to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y,

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TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

VOL. XVII APRIL, 1922 NO. 4

Co-operation Solicited
In Extending Illumination Education

BY AND LARGE, the requisites of good lighting are not known to the extent which they should be. However, too much blame for this situation should not be attached to the Illuminating Engineering Society and its committees. The task of enlightenment has been of enormous proportions, and the rapid development of the subject has added to the difficulty. It is with the hope of enlisting the more active co-operation of the membership generally that the following outline of the work of the present Committee on Education is presented.

The work of the Society along educational lines has been apportioned among four sub-committees: primary and secondary schools, colleges and technical schools, extension work (especially for those connected with the industry) and popular education. It is hard to say which one of these fields is most in need of cultivation. In the public schools little can be done until text-book writers and teachers are educated. The teachers must be reached through normal schools, educational society meetings and other points of contact. Lectures should be particularly effective because of the ease with which impressive demonstrations can be arranged. As for writers, there are appropriate places in many school texts for material on good lighting, but where the subject is now treated at all it is generally from a very inadequate point of view. Among the texts which could include something on illumination are those on hygiene, civics, nature study, elementary science, home economics, physics and even chemistry.

In the colleges, while more should be done to provide courses in illumination for electrical engineers, architects and others, and while such courses, where given, often need to be modernized, the greatest educational opportunity is in introducing a more practical and up-to-date viewpoint regarding light and its uses into courses on physics, phychology, physiology and chemistry, because a larger number of students are required to take these courses. Suitable material on illumination should also be included in some of the special courses such as mechanical and mine engineering, home economics and agricultural engineering. The present status of such educational work is being investigated by the committee and student research in the field of illumination is being strongly urged.

Probably more work has been done on popular education than anything else, but this field is so great that the surface has only been scratched. Lectures before organizations and other groups constitute the principal method which has been employed. Considerable work of this character has been done in the vicinity of New York, and lately a committee of the Chicago section has been formed to work in that district. Similar committees should be formed in connection with each section and chapter of the Society. To facilitate such lectures it is proposed to prepare and make generally available a list of members of the Society, distributed throughout the country, who can be called upon to give addresses.

In attacking the foregoing problems the Committee on Education invites and solicits the co-operation of every member of the society.

F. C. Caldwell, *Chairman,*
Committee on Education.

REFLECTIONS

More Highways to be Illuminated

CONSTANTLY increasing night travel by motor vehicles has brought about a congestion of traffic, accompanied by an appalling succession of accidents, and one result has been a demand for improved highway lighting. A new system has been developed within the past year by the General Electric Company and successfully used on the Albany-Schenectady highway.

Recently the township of Amherst, N. Y. decided to install this system along its highways. This will involve a complete installation of nearly 1,500 units along the highways whose total mileage is about 100. The first units will be placed along five miles of one of the great trunk motor-travel routes leading from the Buffalo city line eastward through the town, and the balance of the installation will be made during the next three years.

This same system is now to be demonstrated on a portion of the Lincoln Highway in Lake County, Ind. Preliminary plans for illuminating one and one-half miles of this highway have been approved by the technical committee of the Lincoln Highway Association.

Electric Signs Prohibited on Fifth Avenue

A DECISION handed down early in March in the Supreme Court of New York State has sustained an ordinance of the city of New York prohibiting electric signs on the fronts of buildings in Fifth Avenue from Washington Square to One hundred and Tenth Street, in Madison Avenue from Thirty-fourth to Seventy-second Street, and in Thirty-fourth and Fifty-seventh Streets for several blocks in the neighborhood of these avenues in New York City.

Judge Vernon M. Davis, who gave this decision, held that the law was not discriminatory and was in the "interest and convenience of the public." This finding opens the way to other municipal legislation restricting electric signs.

Wireless Lights—Interesting if True

BEARING in mind the successive steps in the development of present-day electric lighting sources, showing as it has noteworthy and even sensational advances in successive stages, and remembering the relatively low luminous efficiencies of the best of these sources, it appears practically a certainty that still further improvement or new discovery will follow. Certainly no one would be rash enough to deny this possibility. Consequently this field not only offers promise to the sincere investigator, but provides a plausible opportunity for unscrupulous claimants of new discoveries, serving as bait to the credulous victim ostensibly allowed in on the ground floor. Improvements when they come may be expected in the form of new incandescent filaments and better types of luminous gas discharge, with the remote possibility of some hitherto unrecognized method of obtaining a high luminous efficiency in the phosphorescent or fluorescent field. Consequently fake claims usually masquerade as new types of filament, cold light, the wireless lamp, or other sensational suggestion taken from the field of known opportunity.

But completely revolutionary advances rarely, if ever, occur, and the most remarkable are generally announced through recognized channels of authentic information to the profession concerned. These advances are always found to rest on sound scientific principles, applied more widely, or perhaps on new materials, and their authors invite inspection, criticism and approval. For only in this way can a new device or method obtain adoption.

Therefore all new claims of remarkable discovery, whether in the lighting or other field, should be received with an attitude of "interesting if true," but should be viewed with the utmost suspicion if they are shrouded in mystery or surrounded by guards. Credence should be placed in and support given to them when a complete explanation of the working method is forthcoming and endorsed by a competent expert. *Electrical World,* April 15, 1922.

PAPERS

MERCHANDISING ILLUMINATION*

BY WILLIAM L. GOODWIN**

SYNOPSIS: The author points out the need for applying illuminating engineering knowledge and skill to a large proportion of the lighting installations now being made. If, at present, engineering talent is incorporated in only ten per cent of the jobs, he urges that a way ought to be found to put the illuminating engineer's knowledge at work to improving the other ninety per cent.

The whole lighting industry, he shows, must be helped to make illumination selling and illuminating engineering profitable in a money sense. The giving of free engineering service by (1) the lamp manufacturers, (2) the utility companies, (3) the equipment manufacturers, and (4) the wholesalers is a fundamental error of policy which has the result of closing up the field of the independent consulting illuminating engineer.

So important and varied are the applications of electric lighting that almost any plan or scheme to put the achievements of illuminating engineering into general use by the public would be justified, whatever its cost. How much more essential, then, to inaugurate at this time a great illumination merchandising plan, adopting and applying proven merchandising methods, to obtain for the principles of illuminating engineering a wider actual application in the everyday installations of lighting.

PREAMBLE

The hope of the future, I believe, lies in the engineer. If the engineer can get a true picture of our problems, the answer will be forthcoming. I don't wish it to be understood that I am in any way criticizing present practices or the results that are being accomplished, except regarding the extent that the engineers' knowledge and ability is being realized and utilized by society at large.

If you treat with individual or isolated cases, the accomplishments of the engineers have many outstanding virtues, but when you take the country or the world at large and you realize that the result of your genius and talent is only utilized perhaps to the extent of five or ten per cent of its possibility, then there is an opportunity for criticism, not necessarily the engineer, but all of the practices involved in getting the entire ground over. In other words, it is the eighty or ninety per cent of the untouched field that I am concerned about, and how we can apply your knowledge, your genius, in greater measure, is a thing that I am interested in. In other words, if we have this wonderful engineering talent and for any reason it is only applied in a ratio of ten

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**Assistant to the President, Society for Electrical Development, New York, N. Y.

to one hundred, then it seems to me it is a problem of the engineer to find out why his knowledge can't be applied one hundred per cent.

I have just had occasion to write a paper for the American Electrial Railway Association which will be presented at Atlantic City next week, and in viewing the street railway problem in the broad aspect, there is no question but what a wonderful engineering job has been done, but the fact remains that sixty per cent of the street railway industry is in the hands of the receiver and the other forty per cent is seeking a haven of safety. In other words, the industry is going to destruction and unless we can check this microbe which is in the street railway industry, it is only a matter of a short time until it is going to be in the hands of municipalities, or state ownership and I leave it to you if we can hope for progress under municipality or government ownership. It is a fine thing to talk about; it is hell to live with. It is a great thing in theory, but in practice it doesn't work. Let's carry that thing into the field of illumination. It is a nice thing to talk about, but when we come to its application, we find only five to ten per cent of the markets serve as you would like to be served. How we can get the other eighty per cent is what I am going to try to present in the paper.

THE PROBLEM

In presenting my ideas on the subject of "Merchandising Illumination," I realize full well that my approach to the subject is from the standpoint of the business man whose interest in illumination involves two principal points, satisfied customers and financial profit from the operation.

I recognize full well the primary interest of the manufacturer, who desires to sell his equipment as well as the central station or gas company whose profit comes either from the sale of energy or equipment. Likewise, I recognize the engineering profession, professional ethics and the approach to the problem from the engineer's standpoint. As engineers, I assume you strive for results in product from a scientific standpoint; you look at the completed job in the broad sense from engineering standards realized, and you consider the operation from the basis of maintenance, economics or efficiency standpoint of the completed job.

In the broadest sense merchandising illumination must embody all practices and all variables entering into the completed job, and it is just as important that the constructing engineer, contractor, dealer or actual installer of the job be given consideration as it is that the manufacturer and central station likewise profit from the operation.

It would therefore seem to indicate that our hope lies in the engineer, and that the engineering profession always advocating and maintaining a high standard of professional ethics, will continuously and persistently strive to keep the profession upon such a plane as will compel respect both from the consumer and the trade.

The merchandising of illumination consists in distributing and applying the achievements of illuminating engineers for the use of society at large. The effective marketing of these achievements, in short, is the problem confronting us to-day, and it is a vital one, for while illuminating engineers have enunciated certain principles and methods of lighting which have been applied with gratifying success to some extent, the fact remains that the general practice of lighting still lags far behind the methods known to the engineer. The great public still remains strangely ignorant of or indifferent to the advantages of good lighting.

THE ENGINEER AND HIS DUTIES

The medium through which the illuminating engineer must reach the public with his achievements is the whole lighting industry, and the success of that industry is founded upon the degree of satisfaction it gives its customers by virtue of service rendered. Herein also lies the success of the illuminating expert, for unless he can reach the public—educate the people—his achievements are of little practical usefulness. His duties as an engineer are only half accomplished. He is not a useful member of society unless he contributes to the elevation of the people and this he cannot do without a clear-cut channel for the dissemination of his particular knowledge to the public. His achievements can be valued only in so far as they are appreciated and adopted by the people. In other words, the public must endorse the achievements of the illuminating engineer by putting them to practical use in order that his industry may be justified.

THE COST OF BAD LIGHTING

That the work of the illuminating expert should be unqualifiedly endorsed by the public is clearly indicated in every line of human endeavor. In industrial activities, for example, almost thirty million dollars are wasted annually in the form of spoiled material and inferior workmanship due to poor lighting. For the same reason over one hundred thousand workers are incapacitated by accidents for an average period of twelve months each year. Again, some one hundred and twenty-five thousand preventable accidents occur yearly which would be avoidable if adequate illumination were provided. And, yearly in the United States alone, many hundreds are fatally hurt—all traceable directly or indirectly to bad or inadequate lighting.

That seems to me to be evidence sufficient that knowledge is of no value unless it is capitalized, and used. In order to be used in this electrical industry, it must be, after all, the application of your knowledge as a commercial proposition, and we can't look upon it as a commercial proposition unless we can make money out of our dollars invested. That is the practical side of the question.

SPREADING THE MESSAGE

A general appreciation by the people of such statistics and of kindred records from other lines of activity would doubtless greatly stimulate the merchandising of illumination, but such appreciation is hard and slow to arouse. Furthermore, efforts along this line alone are insufficient. They must be supplemented by the use of the whole lighting industry itself as a medium for the dissemination to the public of the knowledge possessed by the illuminating engineer. This dissemination of knowledge should be *through* the industry to the people, else the message is very apt to miscarry, for the engineer's advice is of necessity couched in more or less technical phraseology which is not always comprehended by the public.

THE MEDIUM

The lighting industry—the manufacturer who produces the equipment needed for the practical utilization of the engineer's contribution; the jobber, or distributor, who supplies the dealer with the manufacturer's product; the dealer who sells it to the public, and the contractor who installs the product; as well as the

central station which supplies the utility service by which the people may make use of the engineer's achievements—each branch should carry the message from the illuminating engineer to the public. Such dissemination of knowledge is entirely feasible. It represents a free and unobstructed flow along the most economic channels. It is a logical movement which it is the plain duty of the whole lighting industry to assume. It is co-ordination of effort and is merchandising based on that selling fundamental expressed by the phrase "Please your customers"—*i. e.*, by rendering service and discharging responsibilities.

THE MANUFACTURER'S PART

The manufacturer interprets the achievements of the engineer in material form. He commercializes these technical accomplishments and provides the practical tools for the material expression of the engineer's acquired knowledge. He must imbibe knowledge and appreciation of the expert's developments in their entirety and must also interpret the needs and desires of the people to the engineer, modelling his own activities accordingly. The manufacturer's place in the development of illumination merchandising is highly important. He must render service to the engineer, to other branches of the industry and to the public. He must produce efficient equipment economically and in its construction must safeguard the public in its proper use.

THE MANUFACTURER'S RESPONSIBILITIES

The manufacturer should standardize his product. In this respect the electric lighting industry—particularly as it pertains to incandescent-lamp manufacture—is probably in advance of almost any other. However, standardization of lighting equipment and all material employed in the installation of lighting systems or in any way affecting the lighting industry must continue with unabated vigor. Standardization is a very necessary link in the scheme of merchandising illumination and is quite as much a part of merchandising as is the direct sale over the counter of the finished product. In fact, standardization is apt to be even more important, for the ordinary store transaction is a simple act entailing the exchange of a commodity for some predetermined sum, frequently without service or discharge of constructive effort and often with evasion of responsibility—which cer-

tainly are not to be classed as constructive merchandising The manufacturer should establish, as well, high standards of quality in product. He owes this to the public and to himself. He must produce economically and must market through the most economical channels. As quantity production is essential both for quality and for economy in production, he should manufacture for stock rather than on order.

THE JOBBER'S PART

The jobber, or distributor, is thus introduced as an essential link in the lighting merchandising chain, with very definite duties and important responsibilities to the other branches of the industry. He may be likened to being "an animated stock bin" for the manufacturer. He distributes the product and should do so understandingly. His contact with the illuminating engineer may not be quite so close as that of the manufacturer, who should in fact be the mechanical engineer interpreting the needs of the electrical engineer, but his knowledge of technical features as resolved into material form by the manufacturer should be comprehensive. It is this knowledge he should disseminate among his dealer customers, the transmission of the engineer's message shorn of the technical details pertaining to design and production. Likewise he should co-operate with the manufacturer in interpreting the wishes and demands of the public as they come to him from the dealer's first-hand contact.

HIS RESPONSIBILITIES

The jobber has an even greater responsibility in that it is through him the product of the manufacturer moves. He is responsible for delivery and to a lesser extent for service. It makes no difference how excellent the product of a manufacturer may be, if it cannot be delivered to the customer when he wants it, the quality of excellence means nothing. It is this delivery that the jobber is responsible for. Again, if the manufactured products are excellent and their delivery beyond reproach, the virtues of both are of little value if the dealer who passes them on to the ultimate consumer lacks the ability to talk intelligently with customers about them. The jobber is responsible for his

dealer's ability to carry on the illuminating engineer's message. The jobber supports the manufacturer, moves the product and lends support to the dealer.

THE DEALER'S PART

The dealer, properly supported by the manufacturing and distributing organizations, must be an enthusiast, familiar with the products he handles, tactful, accommodating, and prepared to render all legitimate service. Enthusiasm is placed first among these essential characteristics, for it is known that the largest proportion of the sales lost by a dealer is due to indifference on the part of his salespeople. Familiarity with products handled comes next, as many of the sales lost are traceable to attempts to substitute other merchandise and almost as many of the failures to errors on the part of the salespeople. An appreciation of the engineer's message, that is, familiarity with the technical features of the product as interpreted by the manufacturer in material form is the best and surest method of avoiding these losses. Substitutions will then occur only when justified, errors will be avoided, and good-will will be established.

REASONS FOR LOST BUSINESS

Other reasons why dealers lose customers need only be mentioned, as the remedy is in each case quite apparent. In order of their importance they are tricky business methods, slow deliveries, over-insistence of salespeople, indifference of employees, unnecessary delays in service, tactless business policies, poor display of merchandise, ignorance of salespeople concerning the merchandise, refusal to exchange purchases and, last, poor quality of goods. All of these faults can be overcome. They are more or less prevalent in all lines of business, but in the electrical business they must be eliminated. The responsibility is great, for it is the electrical industry which can render to the public, in the fullest way, that great service which increases production, reduces the cost of living and augments human safety, efficiency and comfort, and in no branch of the industry are the opportunities greater than in the electric lighting field.

The service which the electrial dealer should rightfully assume carries him into the contractor class, for the installation of the equipment is a responsibility which devolves upon the dealer

in the majority of cases. Even when he does not install, he should arrange with a trustworthy contractor to undertake the installation of the equipment he sells. The contractor, consequently, serves as a highly important link in the merchandising scheme, since the lay public—his clients rather than his customers—should not be entrusted with the installation of electrical equipment. Too many technical responsibilities fall upon the one making the installation.

THE CONTRACTOR'S PART

The importance of the contractor in the merchandising of illumination cannot be overestimated, if he assumes and discharges his full responsibilities. In the final analysis, he should be a practical workman, a salesman and an educator—a student and an authority on lighting regulation, development and practice. He must appreciate the value of proper lighting and realize that his particular function in merchandising illumination pertains more to the provision of facilities for securing proper illumination than it does to the simple provision of connections for some specific lamp, etc. That is, he should co-operate to the fullest possible extent with the dealer to sell illumination rather than lamps. His aim should be to please his customers, and probably no lines offer greater opportunities for so doing than do those pertaining to illumination. Let the contractor remember that the public as a whole is surprisingly ignorant of the advantages of good lighting, it knows next to nothing about the codes and regulations drafted to safeguard its property and interests and even less concerning electricity and sane uses.

HIS OPPORTUNITIES

The contractor has wonderful possibilities when he realizes he is dealing with *illumination,* not so many feet of wire and conduit, outlets, receptacles, fixtures and lamps. Illumination is probably the cheapest "commodity" handled, nobody knows its full possibilities or its true value. Competition between contractors should and can readily be on a basis of quality of illumination provided—of service rendered—not the competition which leads to skimping on work and material.

THE SITUATION

This is not simply an ideal state of affairs to be striven for, but an entirely feasible, practical and logical situation, for the illuminating contractor deals with the cheapest known service, the public is receptive and anxious to benefit itself to the unmost for a minimum outlay, ready at all times to pay for an installation which will prove a good investment. Education of the public in lighting matters is essential, the dissemination to the public of the illuminating engineer's message shorn of unnecessary technicalities by the manufacturer, imbued with commercial and economic explanation by the jobber and dealer, and interpreted to the public by the dealer and contractor. Briefly, the qualified electrical contractor should be able to recognize instantly the chief causes of bad lighting, to explain and demonstrate the effects produced and know the remedies to apply, besides being familiar with the intensities of illumination recommended by the illuminating expert, from whom the other information also originates and percolates through the whole electric lighting industry.

It is very important in order that the expression of the engineer be carried out that the proper machinery be set out. However, it requires a combination of essentials in the contractors or dealers who are charged with the responsibility of making the installation. No general practice can be established throughout the country and what will apply in Rochester will not apply in Utica. In engineering practice you strive for a standard. We are arriving at standards very rapidly, but in the commercial application of your ideas, we have no standards. We can't set down certain formulas that the trade will follow, because there are such variables, depending upon the claims of the manufacturer in each particular community and there we find that the human equation enters to about fifty per cent in the value of the completed job and in any engineering job, the human equation represents about fifty per cent of the value of the finished product.

CONTRACTOR-DEALER OBLIGATIONS

To carry through the engineer's message, the contractor-dealer should:

Educate lamp users to the advantages of more intensive use of lamps and the best means of applying lamps.

Develop new applications for lamps.

Co-operate with manufacturers and jobbers of illuminating equipment, such as reflectors, fixtures, wire, conduits, etc., etc., to assure a plentiful supply of high grade products being on hand.

Co-operate with engineering and trade associations, architects, building contractors, engineers, and others in the interests of good lighting practice.

Advise illuminating engineers and manufacturers regarding the public demand for new types of lamps and for modifications of existing types.

Standardize installations by using standard lamps and equipment so far as possible.

Co-operate in the preparation of all varieties of illuminating engineering publicity.

THE PROGRAM

Ambitious as is such a program, it is entirely feasible, if the contractor-dealer assumes his responsibilities and can visualize his opportunities. It entails, furthermore, co-ordinated efforts on the part of all other branches of the lighting industry along similar lines, a campaign of intensive education within as well as without the industry. Much of this educational work can be very rightfully, logically and effectively carried on through trade papers, trade organizations and similar channels functioning to co-ordinate the various interests in the industry and it would be highly desirable to carry forward the dissemination of the vast stores of knowledge which can and should be contributed by the engineer, the manufacturer, the jobber, dealer and contractor under the guidance of some strong national organization representing, by a directorate and staff of specialists, the whole electrical industry. Perhaps in this respect the S. E. D. with which I am associated may be made a useful and effective agency to this end.

CENTRAL STATION'S OR GAS COMPANY'S PART

This would include the lighting company's interests as well as the more direct and obvious links in the merchandising chain, for without the active co-operation of the lighting company even the most intensive activities in the merchandising of illumination would be of little avail. The lighting company supplies the

energy for operating the product marketed and the lighting business is one of the most, if not the most, desirable in the economic operation and expansion of such plants. They should co-operate in every possible way in merchandising illumination and by slight changes in policy they will become more effective and worthy partners in such a movement for the development of present day civilization. They must be prepared to render adequate and reliable service, necessitating their close and unceasing attention to developments in the illuminating field. They must standardize their service, their voltages and practices. They should be ready to meet sudden demands—in fact, should keep well in advance of the service demands at all times. This, also, is an important phase of merchandising illumination.

Right there, of course, you engineers realize some of the blunders that have been made in the past by this conglomerate mass of voltages and frequencies and current and how present-day development is being retarded due to excessive costs in producing multiplicity of equipment necessary to adaptation to all these various voltages, and frequencies and some standardization of voltages and frequencies plus receptacles and outlets all have a direct bearing on the popularization of illumination. We must make it easy for people to use our product. We must make it simple of understanding, and personally, I believe that the industry has made its problem altogether too complicated and the man on the street can't understand it.

We speak a very peculiar language and we must acquire a new expression in dealing with the public. They are not concerned with watts, volts and amperes, and all are other technical terms that we use in expressing our ideas. The public is interested solely in the result, and if we will talk about results rather than all of the technical features of the job, then popularization will come from the public and that is very important. I think that one of the greatest contributions that has been made to the industry in recent years is this direct reading meter that, as it were, visualizes the result to the consumer. The matter is not whether the expression which he sees is technically correct. He is thinking in terms of relative values, and what matter whether the value presented is accurate or within eighty-five or ninety per cent of accuracy.

If we can visualize to the consumer what he is actually purchasing in illumination, then the business will go forward in great volume, and the direct reading of the meter that has recently been developed and used with great results is one of the greatest contributions to express the knowledge of the engineer that the industry has encountered, and we want more development along that line from the engineering profession.

The illuminating engineer and the public,—the two ends of the merchandising chain,—may well ask whether such an elaborate program is warranted. The one has originated an epoch making service for the good and elevation of mankind, the magnitude of which he may not fully appreciate, despite his special knowledge of the force he has liberated, while the other may find it hard to believe that so careful and comprehensive organization and co-ordination of interests is needed simply that he may have proper light when desired, almost at will and at a cost which brings proper illumination within the reach of all.

The answer is best given by citing a few general statistics. About one-third of the homes in the United States are at present wired for electric service and the large majority of those which are wired are inadequately and improperly illuminated.

OBVIOUS MARKETS

Considerably more than five million other homes in the country are reached by central station lines yet are not even wired for electric service.

The remainder,—over forty-one per cent of the homes of the country have not yet been reached by central station lines, though the great majority of these must eventually be afforded the comforts and conveniences of electric service.

Industrial, commercial and residential lighting opportunities are as great. Then there are the thousands of miles of streets and highways to be lighted and other thousands of miles of streets inadequately lighted at present which offer great markets for the merchandising of illumination. There are all the marine uses for electric lights, the lighting of land transportation systems, vehicle lighting, motor headlights, lighting of rights of way and numerous other fields on, above and below the surface of land and sea offering unlimited opportunities for the installation of proper lighting systems.

When manufacturers and lighting companies concentrate their efforts upon installation of their product, and offer opportunities of profit to other interested groups, commensurate with the value of the service they render, all factors considered—we will have a greater number of individuals and companies promoting the merchandising of illumination.

It is only necessary to point out the many thousands of prospects to convince anyone who is giving serious thought to the subject of the defects in present trade practice. As engineers your inventive talents have produced wonderful results; but the fact remains, that the product of your genius is yet largely a matter of proven, yet unapplied, knowledge.

The practical application of the product of engineering attainment and modern processes of quantity factory production still awaits the call of the actual consumer in tremendous volume. Undoubtedly this is due to the confusion or over-lapping of engineering talents into the field of merchandising activities and vice-versa to an extent that makes the actual merchandising and installing job an unprofitable operation. To accomplish greater results in actual application, we must without destroying the reward for initiative, find ways through modified merchandising methods of offering greater compensation to merchandising talent and those concerns actually functioning in this field, namely the so-called contractor-dealers.

Causes may be cited as examples of existing policy errors.

1st: A lessening of the so-called free engineering services to consumers on the part of lamp manufacturers.

2nd: A lessening of the so-called free services of engineers to consumers on the part of central stations or gas companies.

3rd: A lessening of a so-called free service of engineers to consumers on the part of equipment manufacturers and wholesale distributors.

In other words, without destroying the initiative or the reward of profit, on the part of all three groups just mentioned, we should set up a similar or proper compensation for the man or company or group of those financially responsible for and able to produce the completed installation.

Put another way: If all the so-called free engineering service offered under present practices, to both consumers and contractor-dealers was limited to the trade only, we would shortly create a powerful and competent group of contractor-dealers, whose energy directed solely to merchandising illumination would be reflected in an unprecedented volume of business and a practical application of the hopes and ambitions of the engineer. I feel quite sure that present practice is gradually but surely closing the field to the independent consulting illuminating engineer.

Please do not misunderstand me. I am not criticizing past practices, not saying who is to blame. Perhaps in light of knowledge and experience, our methods have been sound, but let us come down from the clouds for a moment and realize some of the practical habits of nature. What matters and who cares whether the chicken or the egg came first; what does concern us and what we now know is that in order to have good chickens in the future, we must give equal consideration to rooster, hen and egg. A well fed, well cared for, properly bred flock of chickens is of passing moment, if after the eggs are laid they are all consumed. Soon we would have no more chickens, hence no more eggs. The modern incubator and other developments of the engineer (or farmer) may have contributed to the joys and happiness of the hen, but since the hen has not been consulted, how does the engineer know she is happy. Moral: 1. We cannot eat all the eggs and still have the hen. 2. The contractor or the man who sells and installs the completed job is worthy of his hire.

If and when we recognize and apply the moral and the analogy, we will realize that society at large can and will benefit by the genius of the engineer. To do so you men as a class should recognize even to a greater degree all the factors and variables involved in merchandising illumination.

Now let us see if, in the event of such practices being applied, what part the engineer would then perform.

1st. He would become the trade consultant, either by being paid by the trade or retained for industrial consulting advice by manufacturers, either upon a fixed compensation or salary.

2nd. Employment by consumer upon fee, or fee paid by manufacturers or lighting companies for passing on completed jobs.

It would seem to apply then in practice that the talent and energy of the profession should be directed for the moment in the preparation of specifications which would direct the trade and the consumer to an appreciation of proper equipment and modern practices of illumination.

Broadly speaking, the engineering talent in the field of illumination is employed by either manufacturers of lamps and equipment or by lighting companies; in both cases your compensation is included in the price of product or kilowatts. A continuance and expansion of this practice will in time entirely wipe out the profession of illuminating engineering. Already the profession has been commercialized to altogether too great an extent that the industry or trade fails to recognize professional ethics. As you commercialize professional service, your influence is weakened and society at large must suffer the consequences.

The problem of how to bring about a broader use of modern illuminating practice is purely one of applying correct professional and business principles.

It is a combination of an engineering and commercial undertaking and so it is very important that both factors be recognized by each element in the undertaking. If we are to look for initiative in a commercial activity, financial reward must be offered. If the reward for initiative and effort is admitted to be financial gain and we also recognize that manufacturers and central stations apparently have been so rewarded, then what elements in the industry are blocking our progress because of the absence of such financial reward.

A knowledge of the actual conditions existing convinces one that the jobber, the contractor and the dealer have not found the business of merchandising illumination to be a profitable venture. A persistent effort to introduce lighting departments in the jobbing industry under the direction of an experienced illuminating engineer has been met with little interest and in many cases very decided opposition. The jobber's answer is—there is no money in selling lighting equipment other than lamps. Here is a very decided form of sales resistance. A study of the contractor dealer situation presents about the same answer. The

small contractor or fixture dealer does not keep proper accounting record, hence does not know his sources of profit. He thinks he is making money, but the fact remains that the trade at large is sick and the credit standing of most fixture dealers is very unsatisfactory. Generally speaking the business is looked upon as an unprofitable venture.

To the extent that adequate accounting systems have been installed, some startling results have been exposed, *i. e.,* that the fixture dealer has carried forward most of his operations with little or no profit, and the very small percentage of the total work done has carried the load.

In the field of the larger or more competent contractors, many of whom employ competent engineers, the result has been about the same. These concerns do maintain proper accounting records and the final figures in many attempts to merchandise illumination prove conclusively that the profit in the undertaking is not commensurate with the energy expended, the capital invested, and the risk taken. There is a decided indifference on the part of the large contracting engineering company, when any suggestions are made, toward high tension sales effort in this large field of opportunity.

PROPER MERCHANDISING INDISPENSABLE

The field of artificial illumination is so varied, so colossal and so important to the welfare of humanity that any merchandising scheme giving promise of placing the achievements of illuminating engineering in general use by the people would be justified, whatever its cost. How much more essential, then, is the inauguration of a positive campaign for merchandising illumination when all that is needed to assure rapid progress toward the attainment of one of the greatest benefits to modern civilization is the simple, unselfish co-operative effort of a great, well organized industry—each individual assuming the discharge of his responsibility to every other representative in his branch of the industry, each branch its responsibility to every other branch in the industry and the whole industry its responsibility to the public—by the adoption and application of proven merchandising methods.

The electric lighting industry cannot afford *not to* adopt such policy—not any one branch and not any one individual in it.

The outstanding hope, the preparation of a proper code, professional and business ethics, lies with the engineer.

DISCUSSION

G. H. STICKNEY: Mr. Goodwin's paper represents somewhat of an innovation in the character of papers presented before this Society. It has seemed to me that we have not been as successful as we should be in securing the wide practical application of the principles of good illumination enunciated before our meetings. Such knowledge is valuable only as it is applied.

The sales representatives come in close contact with a large proportion of the people who are responsible for lighting installations, and are, therefore, in a position to exert a valuable influence toward bettering the practice.

What can we do to secure this support? Mr. Goodwin's paper gives us some good information along that line, and I hope it will lead to a better co-operation between the engineer and the salesman. It is not to be expected that we will entirely agree at this time. But if we can get a better understanding of each other's viewpoints, I am sure it will help.

Mr. Goodwin has brought up the point of free engineering service. I am not an advocate of giving away service or anything else which costs money. On the other hand, I believe there has been a justification of a certain amount of such service. During an introductory period with any commodity, there is a time when it is necessary for its producer to educate people regarding its use. There was a time when manufacturers of generators had to do installation engineering in order to insure satisfactory results. As soon as consulting engineering was developed, the manufacturers began to withdraw.

In lighting, the withdrawal on the part of manufacturers and central stations has been retarded by two things—first, the rapid advances in illuminants, and second, the large proportion of installations of insufficient magnitude to support paid consultants. I do not think any one need fear that free advice will be continued after the necessity for it decreases. My observation is that the economics of the situation will compel the discontinuation. No well managed company is going to increase its costs unnecessarily.

When I see the large proportion of poor installations, I am not sure but what the service is being withdrawn too fast. Certainly, there is to-day plenty of room for constructive advisors to prove their worth to the lighting clientele. In the organization with which I am connected, we expend our effort in a wholesale way, trying to get out information to customers through engineers, contractors and architects. We handle relatively few problems direct, just about enough to keep our information up-to-date.

The lighting problem is so closely connected with architecture, plant engineering, etc., that I do not expect to see a large number of consultants specializing only on illuminating engineering. Electrical engineers and others will need to come into a bettering understanding of the importance of lighting practices and inform themselves concerning them. Then where there is reasonable assurance that a client can secure good advice, I am sure that the so-called free competition will have disappeared.

E. L. ELLIOTT: We have heard an arraignment of the I. E. S. I think it was in good time, and I am going to assume the position of both counsel for the defense and the chief witness. I may perhaps be pardoned for qualifying as a witness. I think I am the only one present at this convention who was present at the meeting at which the I. E. S. was originally formed, and one of the three who issued the call for that meeting. I was talking illuminating engineering ten years before that. Since that time I have been both on the inside looking out, and on the outside looking in; that is to say, I have been connected at various times both with the manufacturing of illuminating apparatus, and at other times entirely disconnected with commercial interest, and looking at the thing entirely from the outside.

The chief count in the indictment is, that this Society has been in operation fifteen years and has not made an impression on more than ten per cent of those we ought to reach,—which I think is a pretty liberal estimate. When the Society was formed there was no such thing as illuminating engineering, nor an illuminating engineer. We got together to study the problem, recognizing that it should be studied as a special branch of investigation, and the knowledge pertaining to it collected, so that we might eventually arrive at a science of illuminating engineering. The name was largely taken advantage of at the beginning as a

sales slogan. "Illuminating engineers" sprang up from all sources, whose training had perhaps consisted in reading advertisements on the subject. This gave rise to the evil which Mr. Goodwin pointed out in the latter part of his address; that is, the manufacturers and dealers all had "illuminating engineers" whose services were free to the public.

This could not do anything else but discredit illuminating engineering as such. It was too much like the advertising that the patent medicines used to do. They advertised that if you would describe your symptoms to them, they would send you a prescription to fit your case. It would be easy enough to guess what their prescription would be. If the makers of a particular lighting device offer to give free engineering, do you think the public is in any doubt about what is going to be recommended by their engineers?

At the New York convention I presented a paper on "The Ethics of Illuminating Engineering," in which I discussed this particular point. It is a perfectly ethical for a manufacturer to have an illuminating engineer; but it must be understood that his engineering goes no further than showing how to use that particular product to its greatest advantage. He is not qualified to tell you what is the best thing to use among the different devices of the kind on the market. Even though he wanted to be impartial he would sub-consciously favor the thing in which he was directly interested.

As to independent consulting engineers; I remember some three or four years after our Society had been established, a representative from the Curtis Publishing Company called on me in search of information as to where he could find a consulting illuminating engineer, to advise in regard to the lighting of the big new plant which they were then building. I was obliged to tell him I did not know of any independent illuminating engineers. I could refer him to a number, who, so far as knowledge went then, were competent illuminating engineers, but were all in the employ of some manufacturer or lighting interest, but he must expect that, while they would show him all about their own apparatus, their advice would not be impartial.

Mr. Goodwin speaks of the independent illuminating engineer being wiped out. It would not be much of a wipe. I have seen a good many hang out their shingles and try out the game, but I do not know any that have succeeded. I am not acquainted with any independent consulting illuminating engineer to-day that is making a living by that alone. The Society has been unfortunate in the circumstance that light and illumination, being very complicated technically, offers the greatest field outside of medicine—the President-Elect please take notice—for faking of any of which I know. It has been easier to put over fake lighting apparatus for this reason, and the fact has been pretty well taken advantage of to the detriment of legitimate engineering.

This is one of the adverse conditions that the Society has had to work against.

To close, I want to say that I have lately reviewed the TRANSACTIONS of the Society rather carefully from the beginning, and I was most impressed with the very great advance that has been made toward real scientific illuminating engineering. If we keep on at this rate, of which the papers read at this convention constitute a long step, we will not much longer need to be either arraigned or defended.

F. C. CALDWELL: It is certainly very interesting and very gratifying to those of us who have been trying to do some illuminating engineering without being attached to any commercial organization, to find the point of view that Mr. Goodwin has taken, held by one in his position. If this matter is looked at from a broad, economic standpoint there can hardly be any question that engineering work should be done by independent engineers rather than by employees of manufacturing organizations.

The present situation has been a matter of growth; perhaps the most extraordinary thing about it is the remarkably good engineering advice that is generally received from men holding positions as employees of the large manufacturing companies. Of course, this situation is not at all confined to illuminating engineering, and it is true to a large extent in every branch of the electrical industry that the customer expects to get the advice he needs, not from an independent engineer, but from the manufacturer. If we compare this situation with that which Mr. Elliott

suggested in the field of medicine, where every inquirer got a prescription of Peruna, or if the house-builder should get plans from the manufacturer of building materials instead of from the independent architect, we can see whither the engineering profession is tending.

There is one other point I want to emphasize. We are all anxious to see the status of our profession raised, and to see it generally held in even higher regard than the other professions, such as medicine and law, and that it shall not be looked upon as a purely commercial institution. The more we can have independent engineering, the more likely we are to have the profession held in high esteem by the public.

Norman Macbeth: There are just a few points in Mr. Goodwin's paper to which I want to refer. I am sorry that we did not have the paper beforehand to consider it more fully. First, I do not entirely agree with him; I believe that the solution of this problem is in the education of the man-in-between, Mr. Goodwin's man first removed from the customer. Mr. Goodwin has, as I understand his proposition, put the contractor between the engineer and the public. He asks the engineer to get to the public, but over a prescribed route. He gave an excellent analogy of the egg and the chicken in evading responsibility for the present unsatisfactory situation.

I heard a similar story the other evening handled in a slightly different manner, which I think may suggest a successful method, or result at least in an analysis of the difficulty. The question came up regarding a man who was exceedingly successful in the development and training of hunting dogs, and he was asked how he did it. He said, "Well, I will tell you. I breed a large number, train a few good ones and hang a lot."

And that is about the situation we have to-day. If Mr. Goodwin can give us a "give-and-take" distributor-contractor by training, or by selection, and properly classify the balance then we may get somewhere on his route.

I do not agree that under present conditions the manufacturers' engineering service should be curtailed, let us have more and yet more of it. Let every different lamp label have its free engineer

to confer with its customer; also every reflector manufacturer, each fixture man, and assembler have his scientific interpreter. When that time arrives; when we have a number of different manufacturers with conflicting advice from their various illuminating sales engineers, so that the consumer cannot possibly choose between them, he will then probably be able to find a satisfactory consulting engineer who will tell him what to do. That is the route travelled in the past by the consulting electrical engineer and, with the exception that the competition in the lighting field is materially less, I can see no other method for a successful result. Furthermore, as far as I am aware there are at the present time relatively few consulting illuminating engineers not at present, or not recently, retained by a manufacturer of lamps or accessories.

S. E. DOANE: This convention will go down in my recollection among other things for this notable paper Mr. Goodwin brings to us. He is among the first of those prominent in trade to make so clear a statement of the great value of illuminating engineering.

I do not believe in achieving our ends by prohibitory laws. I do not think Mr. Goodwin means what he says when he tells the manufacturers they should diminish that service. I think the manufacturers are stepping in and saving the situation from going to pieces.

I do believe in education. With that part of Mr. Goodwin's paper I am in thorough accord. I think that is the way to accomplish our ends, to see that our knowledge is made available. I think you will agree we are making rapid progress in that direction, and I would like to lend my voice to Mr. Goodwin's suggestion excepting in just the ways he suggests.

W. L. GOODWIN (in reply): Perhaps I did not make myself clear. I have no thought that the activities of the engineering service on the part of the manufacturer shall be lessened, but I did advocate in the paper that these energies be directed along other lines. In other words, the energies and talent of the engineers in the employ of the manufacturer and public utility company could be directed to a greater extent on the education of the trade to the end that the trade will profit from their service. I think we want more engineering talent in the industry, but we want a lesser amount of so-called free engineering talent. There

is no such thing as free engineering service. You either pay for the services as such, or you pay for it in the product. The fee for engineering service is included in the price of the product, but the man who does the installing can not get a profit from his service because the manufacturer sells to a wholesaler; who in turn sells to the industrial, at the same price as it is sold to the contractor-dealer. If then, in addition the central station or the manufacturer furnishes the engineering service free, "so-called free service," that is to say, includes it in the price of his product and the jobber employing a so-called illuminating engineer, sells his product and includes a so-called free engineering service as a part of the price of the product when it comes to the actual carrying out of the installation. The contractor has nothing to sell but labor. He can not ask anything for engineering service because that is already covered in product and energy value. He can not add anything on to the product because that is already covered by the manufacturer and jobber in product or in the services they render so the actual installation becomes one of labor and since labor in the building industry is highly organized and controlled, you can realize that it is next to utterly impossible for any contractor to make a profit off labor and so the indifference of the contractor has set up a resistance that we now find difficult to overcome.

Now, if engineering talent can be directed toward advising the trade or can be sold as professional services to the consumer either in planning or checking the final installation, then we will get somewhere. In other words, let us direct the engineering talent on the trade and where we direct it on the public, let us put it in the same position practically as the National Fire Protection Association and Electrical Codes. In other words, the engineer becomes the interpreter for the consumer and tells him whether he gets what he pays for or not and in that way I think the manufacturers would increase the number of engineers in their employ; the dealers would become inspired and encouraged because they would see a profit for their operation and the whole process would speed up.

Now, I think that is a very simple operation and there is no thought of decreasing the importance or value of engineering service, but simply directing it in the most productive channels.

GENERAL SECRETARY'S REPORT FOR THE FISCAL YEAR 1920-1921

BY CLARENCE L. LAW

INTRODUCTION

The fiscal year extending from October 1, 1920, to September 30, 1921, was the fifteenth year of the Society's activity. In general the influence of the Society for the cause of better lighting has maintained the standard of previous years. An increasing service has been rendered to the lighting art and the advancement of the theory and practice of illuminating engineering has been carried forward. With the problems of adjustment following the war conditions, the Society has functioned within its income, and has a record of achievement which is satisfactory to the officers, and, it is believed, quite acceptable to the membership.

Sections and chapters have in general shown consistent interest and good attendance at meetings held throughout the year; the papers presented have been interesting and of high standard.

Two new chapters have been established during the year. The Cleveland Chapter was authorized by the Council at the January meeting; the Toronto Chapter was authorized in May. It is very gratifying to form this alliance in the interest of illumination in the Dominion of Canada.

Special mention should be made of the splendid increase in the number of sustaining members and the revenue from this new source.

The Committee on Lighting Legislation has prepared a revision of the "Code of Lighting Factories, Mills and Other Work Places," which will be submitted to American Engineering Standards Committee for approval as an "American Standard."

COUNCIL

The Council of the Society during the past fiscal year held nine consecutive regular monthly meetings, and the Executive Committee which met in July, August and September transacted the

necessary business. A meeting of the Council was held during the convention in September, to which members of the 1921-1922 Council were invited. The supervision of the affairs of the Society was carried on with the same degree of interest and earnestness that has always been characteristic of the officers of the Council. Mr. Preston S. Millar was appointed director, by the Council on Oct. 6, 1920, to fill the unexpired term of Mr. J. J. Kirk, resigned. Mr. D. McFarlan Moore was appointed director on March 10, 1921 to replace Mr. E. C. Crittenden, resigned. Dr. Geo. S. Crampton resigned on Sept. 28, 1921 as Vice-President and Mr. D. McFarlan Moore was appointed to fill the unexpired term. Mr. G. Bertram Regar was appointed director to fill the unexpired term of Mr. Moore.

The attendance of the officers of the Society at Council meetings has been all that could be expected, most of the officers having attended one or more meetings, while some attended each meeting. The average attendance for the year was eleven officers.

GENERAL OFFICE

In July the General Offices were moved from the eighth floor to the sixteenth floor of the United Engineering Building.

During the past year a change has been made in the personnel of the General Office staff. The former Assistant Secretary resigned in November, 1920 and in January, 1921, Dr. Ralph C. Rodgers was appointed to the office.

MEMBERSHIP

The membership of the Society is divided into four classes; member, associate member, student member and sustaining member. It may be of interest to note some statistics regarding each class in order to convey some idea of the membership status.

Sustaining Members. From this source is derived the largest revenue, which is approximately 32 per cent of the total revenue of the Society. As of Sept. 15, 1921, the sustaining members were eighty-seven in number and had contributed an annual income of $7,440. The corresponding figures for the last year show fifty-six sustaining members who contributed an income of $3,930. The

increase in revenue for the past fiscal year from this source was $3,510 or an increase of 89 per cent. This is extremely gratifying and is an indication of the possibilities in the direction of further increases. Although the society may have nothing tangible to show as a result of sustaining membership, there can be most assuredly pointed out advantages accruing to companies as a result of affiliation. To this class of membership the Society will assist as far as possible in the direction of furnishing information of any character pertaining to illuminating engineering.

Members. From this source is derived 24 per cent of our revenue. The number of members this year is three hundred eighty-four as compared with three hundred ninety-one at the end last year, a net loss of seven; on the other hand the revenue derived this year was $5,500 against $3,830 of last year, an increase of 43 per cent. This is caused by the advance in the amount of members' dues from $7.50 to $15.00 per year.

Associate Members. From this source is derived 25 per cent of our revenue. The number of associate members this year is seven hundred ninety-nine as compared with eight hundred twenty-two of last year, a net loss of twenty-three, on the other hand the revenue received this year was $5,750 against $3,947 of last year, an increase of approximately 46 per cent. This increase is due to raising the dues from $5.00 to $7.50 per year for this class.

Student Members. Inasmuch as the dues for this class were only fixed by the Council this last spring, there has been no great activity in obtaining new members of this class. There is a promising field for effort in this direction through the medium of our chapters, and it is hoped that during the college year this class of membership will be fostered.

In Table I is found a detail summary of the total membership of the Society for the present fiscal year. Fig. 1 shows the total membership at the end of each year from 1906 to date.

TABLE I.

Class of membership	Honorary members	Members	Associates	Total	Sustaining members	Contributors
Membership Oct. 1, 1920	2	391	822	1215	56	
Additions						
Transferred		7	1			
New members qualified		27	111		33	2
Reinstated			7			
Re-elected		1	1			
Sub-total		35	120			
Deductions						
Died		3	6			
Resigned		16	51		2	
Dropped		22	79			
Transferred		1	7			
Sub-total		42	143			
Decrease		7	23	30		
Membership Oct. 1, 1921	2	384	799	1185	87	2
Net Decrease during Year in Membership		7	23	30		

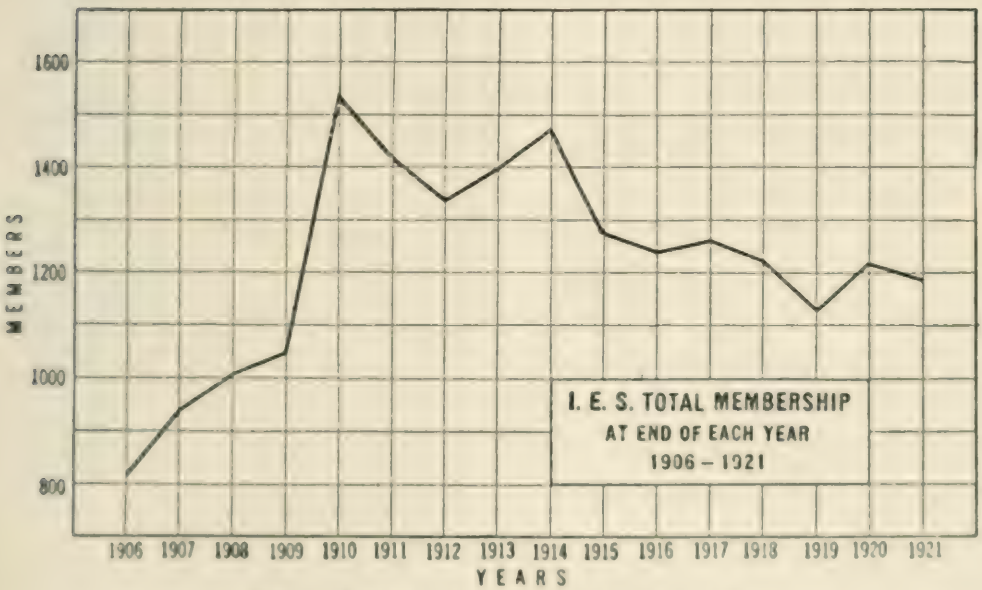

Fig. 1.—Variation in Membership since 1906.

LOCAL REPRESENTATIVES

The Local Representatives of the Society now number thirty-nine, and are situated in twenty-three states of the Union, in Australia, Canada, and South Africa; in September, 1915, the Society had nine Local Representatives.

The functioning of the Local Representative is important and offers great possibilities in furthering the activities of the Society. Every state in the Union should have at least one Local Representative to promulgate the aims and objects of our Society.

SECTIONS AND CHAPTERS

An increasing interest on the part of many who are not members of the Society is indicated in the annual reports received from the various sections and chapters. The policy of holding joint meetings with other organizations and technical societies by the sections and chapters has proved fruitful in bringing about this added interest. The papers discussed at these meetings were of value and a large number of them have been published in the TRANSACTIONS.

Many valuable suggestions were included in these annual reports for improvement in the management of the sections. These items covered details of attendance, exhibition, membership, papers, and publicity.

The following table gives the average attendance, and the number of papers presented at the Section and Chapter meetings.

TABLE II.

Section	Number of meetings	Papers presented	Average attendance
Chicago	4	4	60
New England	5	5	45
New York	8	22	160
Philadelphia	6	6	39
Chapter			
Cleveland	4	4	50
San Francisco Bay Cities	4	6	54
Toronto	4	2	120

COMMITTEES

During the past year twenty-five committees were appointed by the President and the Council; the work of these various committees have been very satisfactory. The Committee on Lighting Legislation has completed a revision of the Code of Lighting Factories, Mills and Other Work Places and this code has been

submitted to the American Engineering Standards Committee for approval as an "American Standard." Following are abstracts from the various committee reports which are on file at the General Office.

Committee on Papers: Many excellent papers were submitted to this committee as evidenced by the material published in the TRANSACTIONS during the fiscal year. From a large number of papers and reports available for the annual convention twenty-nine were selected for the program covering scientific, technical, commercial and general subjects on illumination. There were issued for distribution prior to the convention preprints of twenty-two of these papers and reports.

Responsibility for the work of the Committee has been subdivided, the chairman assuming the preparation of the papers program, and the vice-chairman the action on manuscripts submitted. The Committee has been called upon for much painstaking labor and will retire with the assurance of having rendered a constructive service to a constructive organization.

Committee on Editing and Publication: The chief work of the Committee has been the editing and printing of publications of the Society. Due to a printers' strike in May, the regular issues of the TRANSACTIONS were delayed for several months.

Committee on Progress: The annual report[1] of this Committee consisted of the usual extensive abstract of articles in the foreign and domestic scientific and technical journals. The material for the "Illumination Index" has been published in each issue of the TRANSACTIONS and has proved to be of great value as a source of reference.

Board of Examiners: This Committee, acting for the Council, has carefully investigated the qualifications of all applicants for membership, and during the fiscal year one hundred and seventy-one applications to the various grades were approved.

Committee on Membership: Through the efforts of the Committee one hundred and thirty-eight new members were added to the Society during the fiscal year, the number of sustaining

[1] Report of Committee on Progress, TRANS. I. E. S., 1921 Vol. XVI, p. [illegible]

members were increased by thirty-three, which is a very satisfactory record.

Committee on Nomenclature and Standards: The 1921 report of this Committee as published in the TRANSACTIONS served as the official report,[2] therein is a mention of the problems studied at the Paris meeting of the International Commission on Illumination, as well as the definitions adopted by the Commission. The Committee also recommended the term "luminaire" in the matter of a generic term for "lighting unit."

Committee on Lighting Legislation: The published report[3] of this Committee brought forth the revision of the Code of Lighting Factories, Mills and Other Work Places.

Committee on Education: The work of spreading the propaganda of good lighting has been carried forward by this Committee through various channels. Special attention has been given to extension education, colleges and technical schools, and popular education. Members of the Committee have given lectures and demonstrations throughout the country.

Committee on Sky Brightness: The convention report as published in the TRANSACTIONS[4] served as the official report of this Committee.

Committee on Motor Vehicle Lighting: The published report[5] of this Committee served as the official report. The regulation of automobile headlighting in accordance with the I. E. S. system has made considerable progress during the past year; ten states in the Union, and the Province of Ontario have adopted the system, while Massachusetts has adopted the system in principle.

Committee on Reciprocal Relations:—During the past year this Committee has brought the industrial lighting demonstrations to the attention of local and national societies. Various members

[2] Report of Committee on Nomenclature and Standards, TRANS. I. E. S., 1921, Vol. XVI, p. 246.

[3] Report of the Committee on Lighting Legislation, TRANS. I. E. S., 1921, Vol. XVI, p. 359.

[4] Sky Brightness and Daylight Illumination Measurements, TRANS. I. E. S., 1921, Vol. XVI, p. 255.

[5] Present Status of Automobile Headlighting Regulation, TRANS. I. E. S., 1921, Vol. XVI, p. 499.

of this Committee have made addresses before joint meetings of the I. E. S. and other organizations as well as before national conventions of other societies whose interests are allied with the field of good lighting.

Committee to Co-operate with Fixture Manufacturers: A tentative report[6] was made at the annual convention in September of the activities of the committee in the absence of the Chairman.

Committee to Prepare a Bulletin on the Lighting of the Home by Electricity: This Committee was organized in June and the chapters of the Bulletin are in preparation. Tentative material for the Bulletin was shown at the Convention in Rochester.

Committee on Artistic Treatment of Interior Lighting: A collection of photographs of artistically lighted interiors, and interesting data pertaining thereto has been gathered by the Committee.

Committee on Research: Organized for work late in the spring under the chairmanship of Dr. E. P. Hyde; definite plans were held in abeyance until the late summer for the return of Dr. Hyde from Europe.

Committee on Revision of the Constitution and By-laws: The revision of the Constitution and By-laws was completed. The revised By-laws were adopted by the Council, as a result of a letter ballot, on April 14, 1921, and were published in the TRANSACTIONS.[7]

Committee on Finance: This Committee audited the bills and made out the monthly voucher lists and financial reports, presenting them to the Council meetings throughout the year. The auditor's report required by the Constitution of the Society is appended hereto, including a statement of receipts and expenditures for the past year. It is gratifying to note the healthy condition of the finances of the Society at the end of the fiscal year 1920-1921.

[6] Activities of the Committee to Co-operate with Fixture Manufacturers. TRANS. I. E. S., 1922, Vol. XVII, p. 44.

[7] Constitution and By-Laws of the Illuminating Engineering Society. TRANS. I. E. S., 1921, Vol. XVI, p. 57.

APPENDIX

Illuminating Engineering Society,
29 West 39th Street,
New York City.

Dear Sirs:

Pursuant to my engagement, I have audited the accounts of your Society for the fiscal year ending September 30, 1921, and present appended hereto the following Statements:

Exhibit 1—Balance Sheet—September 30, 1921.

Exhibit 2—Income and Expenses—For Fiscal Year Ending September 30, 1921.

Income is accounted for on the accruing basis and the accounts receivable related thereto unpaid at September 30, 1921, are shown classified in the Balance Sheet.

The cash balances were proved; accounts receivable proved at the figures shown; inventories were investigated. The Liberty Bonds were not examined, but are in the custody of the Treasurer.

The Net Income of the year was $4,402.17 to which are added minor items aggragating $11.29 pertaining to prior years, making the Total Net Income $4,413.46.

There was a deficit at the first of the year of $566.16 which deducted from the Total Net Income leaves a Net Surplus of $3,847.30 at September 30, 1921.

Respectfully submitted,
KENNETH FAIRBANKS,
Certified Public Accountant.

EXHIBIT I

BALANCE SHEET—SEPTEMBER 30, 1921

Assets

Cash in Bank and Office		$2,459.40
Liberty Bonds		3,000.00
Accounts Receivable:		
Members' Dues	$ 15.00	
Associate Members' Dues	13.75	
Sustaining Members' Dues	560.00	
Initiation Fees	5.00	
TRANSACTIONS	34.30	
Advertising	68.50	
Miscellaneous	5.65	702.20
Inventories:		
Badges and Reprints	148.00	
TRANSACTIONS—Illustration Cuts	300.00	448.00
Furniture and Fixtures		585.30
		$7,194.90

Liabilities

Accounts Payable		$ 696.11
Dues and Fees Paid in Advance	$150.99	
TRANSACTIONS Paid in Advance	.50	151.49
Loan for Educational Purposes		2,500.00
Surplus		3,847.30
		$7,194.90

EXHIBIT 2

INCOME AND EXPENSES FOR FISCAL YEAR ENDING SEPTEMBER 30, 1921

Income

Members' Dues	$5,707.50		
Associate Members' Dues	5,820.99		
Sustaining Members Dues	8,112.50	$19,640.99	
Initiation Fees		230.00	
Back Dues		45.00	
TRANSACTIONS Sales		817.96	
Advertising Sales		1,393.66	
Miscellaneous Sales		88.65	
Royalties on Sales		37.80	
Interest—Bank	106.72		
Interest—Liberty Bonds	108.75	215.47	
Total Income			$22,469.53

Expenses

TRANSACTIONS		$ 4,535.36	
General Office Expenses:			
Salaries	7,109.05		
Rent	1,385.00		
Printing, Stationery, Supplies	781.10		
Postage	342.03		
Telephone, Telegrams, Express	240.47		
Miscellaneous	421.26	10,278.91	
Committee Expenses	356.39		
Committee on Education—Expenses	317.05	673.44	
Educational Course Preparatory Expense		151.16	
New York Section	583.88		
Philadelphia Section	636.18		
Chicago Section	192.05		
New England Section	159.36		
San Francisco Chapter	13.25		
Cleveland Chapter	26.50		
Toronto Chapter	13.85	1,625.07	
Convention Expenses		803.42	18,067.36
Net Income—Current Year			4,402.17
Adjustments, Prior Years			11.29
Total Net Income			$4,413.46
Deficit—October 1, 1921		566.16	
Net Income as Above		4,413.46	
Surplus—September 30, 1921		$3,847.30	

SOCIETY AFFAIRS

SECTION ACTIVITIES

NEW YORK

Meeting—March, 1922.

A very interesting meeting of the New York Section was held at the Cafe Boulevard on March 23, 1922, at which Mr. George Schladt, of the Engineering Division, Ordnance Department, U. S. Army read a paper, "Illumination for Aircraft." Mr. Schladt reviewed the manufacture, use and the development of flares during the war period. After the presentation of the paper an interesting discussion was held.

Before the meeting a table d'hote dinner was served to about twenty-two members. There were present at the meeting thirty-five members and guests.

NEW ENGLAND

Meeting—April, 1922.

The New England Section met on April 7, 1922, at the Engineers' Club. Mr. Ward Harrison, National Lamp Works of Cleveland, Ohio, presented a paper, "Principles of Illumination," which was accompanied by a demonstration of apparatus. There was an interesting discussion and the meeting was a very great success. About forty-five members and guests were present.

PHILADELPHIA

Meeting—March, 1922.

A joint meeting of the Philadelphia Section with the Lighting Fixture Dealers Society and Lighting Fixture Manufacturers of Philadelphia was held at the Engineers' Club on March 14, 1922.

Mr. Emile G. Perrot, architect, presented a paper, "Aesthetic and Utilitarian Value of Lighting Fixtures," and Mr. Stepan de Kosenko, Sterling Bronze Company, New York City, presented a paper, "History and Utilization of Lighting Fixtures." Mr. Perrot gave a brief description of the various types of architecture, illustrating them with lantern slides of buildings located in various parts of the world. He then showed pictures of different types of lighting fixtures, by themselves and as installed in various buildings, calling attention to the necessity of designing the fixtures to harmonize with the architectural features of the room in which they are to be used. Mr. de Kosenko described the problems and difficulties the designers of lighting fixtures have to meet. He also made the suggestion that the Illuminating Engineering Society could perform a much to be desired undertaking if they would attempt to standardize the various materials and their characteristics used in the construction of fixtures.

The dinner at the Engineers' Club preceding the meeting was attended by fifty members and guests of the three societies; there was a total attendance of ninety members and guests at the meeting.

TORONTO

Meeting—March, 1922.

The Toronto Chapter met at the Chemistry and Mining Building of the University of Toronto to hear an illustrated lecture, "School Lighting," presented by Mr. Davis H. Tuck, Holophane Glass Company, New York City.

Good and faulty lighting installations were illustrated and a fine discussion ensued on the technic connected with the general subject. About twenty-seven members and guests were present.

COUNCIL NOTES

ITEMS OF INTEREST

At the meeting of the Council on April 13, 1922, the following were elected to membership:

Five Members.

LEON BEAUCHAMP,
Elec. Engineer and Sales Manager,
The Solex Company, Ltd.,
1202 St. Lawrence Blvd.,
Montreal, Canada.

JAMES CLOYD HERRON,
President and General Manager,
Reflector and Illuminating Co.,
565 West Washington Street,
Chicago, Illinois.

JOHN SAMUEL REUBENS,
Assistant Engineer,
Tata Power Co., Ltd. of Bombay,
Kalyan, Bombay Presy, India.

RALPH C. STUART,
Superintendent Lamp Department,
Canadian Westinghouse Co., Ltd.,
Aberdeen Avenue,
Hamilton, Ontario, Canada.

ROLAND R. TILESTON,
Illuminating Engineer,
Colorado Springs Light, Heat and Power Co.,
Colorado Springs, Colorado.

Seventeen Associate Members.

GEORGE R. ANDERSON,
Professor,
University of Toronto,
Toronto, Canada.

DR. W. F. BOILER,
Professor of Ophthalmology,
State University of Iowa,
Iowa City, Iowa.

CLARENCE CARSON,
Research Engineer,
Dodge Brothers,
Detroit, Michigan.

JESSE A. COOK,
Sales Engineer,
Commonwealth Edison Company,
72 West Adams Street,
Chicago, Illinois.

JOHN R. FENNIMAN,
Asst. Gen. Supt.,
Consolidated Gas Co. of New York,
130 East 15th Street,
New York, N. Y.

CHARLES THOMAS HENRY,
Electrical Contractor,
13 West 42d Street,
New York, N. Y.

G. T. HOWARD,
Althoff-Howard Electric Company,
314 First Avenue,
Evansville, Indiana.

ARTHUR A. HUFFNAGLE,
Commonwealth Edison Co.,
72 West Adams Street,
Chicago, Illinois.

DR. EDWARD DANIEL HURLEY,
Oculist,
419 Boylston Street,
Boston, Mass.

I. L. ILLING,
Illuminating Engineer,
The Milwaukee Elec. Railway and Light Company,
Public Service Building,
Milwaukee, Wisconsin.

PAUL F. KAUFFMAN,
Salesman,
Commonwealth Edison Company,
72 W. Adams Street,
Chicago, Illinois.

EDWIN RICHARD MARTIN,
Asst. Prof. Elec. Eng.,
University of Minnesota,
Minneapolis, Minn.

CARL E. NORD,
Owner,
Lumo Sales Company,
521 Sixth Street,
Sioux City, Iowa.

CHESTER W. SNYDER,
Sales and Advertising Mgr.,
Blumenthal-Kahn Elec. Company,
505 North Eutaw Street,
Baltimore, Maryland.

DAVID SPINDELL,
Electrical Contractor,
331 Kosciusko Street,
Brooklyn, New York.

R. L. SUNSTEDT,
Lighting Specialist,
Westinghouse Elec. and Mfg. Co.,
Seattle, Washington.

L. E. WHEELER,
Street Lighting Specialist,
Westinghouse Elec. and Mfg. Co.,
Pittsburg, Pa.

One Transfer to Associate Membership

S. W. VAN RENSSELAER,
X-Ray Reflector Co. of New York,
31 West 46th Street,
New York, N. Y.

Two Sustaining Members

MAX SCHAFFER COMPANY,
26 Warren Street,
New York, N. Y.

CENTRAL ELECTRIC COMPANY,
316 S. Wells Street,
Chicago, Illinois.

CONFIRMATION OF APPOINTMENTS

The appointment of the following committee members were confirmed.

As members of the General Convention Committee

Cyrus Barnes
Louis Bell
Roy R. Burnham
John C. D. Clark
C. A. B. Halvorson, Jr.
Arthur B. Lisle
A. L. Powell
Frank S. Price
Howard T. Sands
Bowen Tufts

As members of the Committee on Advertising

T. J. McManis
H. S. Grace, advisory member
Norman Cantrell, advisory member

COMMITTEE REPORTS

Progress reports were presented from the following: Committee on Editing and Publication, Committee on Membership, Committee on Sky Brightness,

Committee to Co-operate with Fixture Manufactures, Committee to Prepare Bulletin on Residence Lighting by Electricity, Committee on Advertising.

Consideration of the Request from the Society of Electrical Development that the I. E. S. Appoint a Committee to Co-operate with them in Order to Prevent a Duplication of Activities. Council moved to appoint the President, Junior Past President and General Secretary on this committee.

Invitation from Carnegie Institute of Technology to Send Delegates to the Second Conference on Commercial Engineering to be Held May 1 and 2, 1922. Prof F. C. Caldwell was appointed a delegate to this conference.

NEWS ITEMS

CONCERTED MOVEMENT FOR BETTER BUSINESS

At the invitation of Milan R. Bump, President of the National Electric Light Association, members of various electrical organizations and branches of the electrical industry met with the Association officials on January 9th, 1922, to consider the organization of a combined movement for Business Development.

This was enthusiastically endorsed, and realizing that concerted action is essential, the Joint Committee for Business Development was organized with headquarters at the offices of the National Electric Light Association.

The electrical organizations and the leaders of the electrical industry are earnestly co-operating in this movement, which has for its purpose no less an object than to "ELECTRIFY" America.

The activities of the Joint Committee for Business Development are at present grouped under five general headings, or subjects. Each subject is the title of a Guide Book and Chapters of each Guide Book have been issued in booklet form as follows:

Guide Book I— Organization Plans
Chapter I—General Outline

Guide Book II— Lighting
Chapter I—General Outline

Guide Book III— Appliances
Chapter I—General Outline

Guide Book IV— Wiring
Chapter I—General Outline

Guide Book V— Industrial Power
Chapter I— General Outline

The Guide Books and Chapters have been standardized in size and appearance, so that they can be used to form a ready reference library on the general subject of Business Development. The size of the booklet will be 8 inches x 11 inches and each will comprise 8 to 32 pages.

The slogan adopted is "Electrify." This slogan is to be used everywhere. Not only will it be used particularly as a slogan, but it was also adopted to be used in electric and illuminated signs, advertisements, for letter heads, etc. A typical border has been adopted for the word. The word "Electrify" and the border are very simple in design.

It is not the purpose of the Joint Committee for Business Development to promote this movement as a campaign. Instead it is a movement to extend over a period of years, and which will have for its purpose a general quickening of the business of all branches of the electrical industry.

NAVY DISTINGUISHED SERVICE MEDAL AWARDED TO GENERAL HARRIES

Past-President Geo. H. Harries was arded the Navy Distinguished Service edal by President Harding. General rries is one of a few men to have en honored as a recipient of both the vy and the Army medals for distin- ished service in the World War. The lowing letter contains the citation for award.

THE SECRETARY OF THE NAVY
Washington
April 11, 1922

:-

The President of the United States es pleasure in presenting the DISTIN- ISHED SERVICE MEDAL to

BRIGADIER GENERAL
GEORGE H. HARRIES, U. S. A.,

services during the World War as forth in the following:

TATION:

"For distinguished service during the rld war in a position of high respon- ility when, as Commander, U. S. my Base Section Five, Brest, France, by his marked executive ability, ad understanding of our problems, failing courtesy and a constant will- ness to co-operate, materally assisted Navy in its arduous work on the ench Coast."

For the President.

(signed) EDWIN DENBY

Secretary of the Navy

GENERAL OFFICE NOTES

Copies of the following issues are desired:

Vol. XIV, No. 9, Dec. 30, 1919.

Vol. XV, No. 2, Mar. 20, 1920.

Vol. XV, No. 7, Oct. 10, 1920.

Vol. XVI, No. 3, April 30, 1921.

The General Office will pay fifty cents each for copies in good condition of these issues.

PERSONALS

Mr. Charles Franck, Manager of the Holophane Glass Company, Inc., New York City, has left for a three months' trip in Europe. He will tour Germany, Switzerland and France, spending most of the time visiting friends and former business associates. Mr. Franck was Manager of the Holophane Company in Brussels for several years and left Belgium to become Manager of the American Company.

Dr. H. H. Kimball of the United States Weather Bureau sailed from New York City for Naples on April 8. While in Italy Dr. Kimball, as one of the delegates from the United States, will attend the meetings of the International Union of Geodesy and Geophysics at Rome, beginning in the first week of May. He will return to Washington in the early summer.

ILLUMINATION INDEX

PREPARED BY THE COMMITTEE ON PROGRESS.

An index of references to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

		DATE	PAGE
Annales de Physique			
Recherches sur le rayonnement nocturne et le rayonnement solaire aux altitudes elevees—	A. Boutaric	1922 Jan.-Feb.	54
American Gas Journal			
Gas Street Lighting—Is It to Be Discarded?—	F. Victor Westermaier	Feb. 18	159
Incandescent Mantle Gas Lamps—Washington, D. C.—		Feb. 18	168
Central Station			
Influence of Street Lighting on Crime	E. A. Anderson	Feb.	217
Better Lighting Raises Efficiency of Operation—	W. Harrison	March	249
The Amount of Daylight in Lamps—		March	254
Chemical Abstracts			
A New Form of Mercury Vapor Pump for High Vacuum—	J. Palacios	Mar. 10	665
Cold Light—	G. A. Percival	Mar. 10	685
The Manufacture, Properties, and Employment of Heat Intercepting Structural Glass—	G. Alleman	Mar. 10	805
Chemical and Metallurgical Engineering			
Grain Growth and Recrystallization in Metals—		Feb.	343
Comptes Rendus		No. 6	
La projection de la lumiere des etoiles doubles periodiques et les oscillations des raies spectraies—	M. G. Sagnac	Feb.	376
Electrical Merchandising			
The Fixture Market at Milwaukee—		Feb.	60
Electrical News			
Bonspiels—Yesterday and To-day—Electric Illumination of—		Mar. 1	38
Electrical Times			
Floodlighting Hoardings—		Feb. 9	140

Electrical World			
Lamps and Lighting—	Ch. Dantin	Feb. 18	342
Non-Ventilated Units for Lighting Show Increase in Use—		Feb. 25	387
Electrochemical Society, Paper No. I			
The Measurement of Pressures in Vacuum Type Electric Lamps—	Res. Lab. of Westinghouse Co.		
Elektrotechnische Zeitschrift		1921	
Physiologie der Gesichtsempfindung—	R. Spuler	Oct. 27	1229
Die Lichtfarbe—	Fischer	Nov. 3	1255
Beleuchtung und Heizung—		Nov. 3	1268
Ein neues Strahlungspyrometer zur Messung hoher Temperaturen—	G. Keinath	Dec. 1	1384
Gas Age-Record		1922	
Progress in Gas Lighting—		Feb 11	168
Safety Factor Important in Gas Street Lighting—		March 4	262
Gas Journal			
Adapting Mantles to Gas Quality—		Feb. 8	315
Inverted Burners at Newcastle-upon Tyne—Changing over from the Upright System—		Feb. 8	329
(Supplement) Comparative Costs of Lighting by Gas and Electricity Excluding Installation and Maintenance Expenses—		Feb. 22	12
Das Gas und Wasserfach		1921	
Richtige Beleuchtung von Eisenbahn-Anlagen—		Dec. 31	869
Beleuchtung von Hallen durch Tiefstrahler—	Von Heyck	1922 Jan. 7	13
Die Theorie des Beck-Lichtbogens—	H Beck	Jan. 7	13
Helios			
Ica-Projektionsapparat fur Licht- und Strassenreklame—		Jan. 1	3
House Beautiful			
Electric Lighting of an Old Colonial House—	G. L Stodola	April	309
House and Garden			
Lamps for Day and Night—	Elsie de Wolfe	April	46
Illuminating Engineer		1921	
Recent Developments in Illuminating Engineering—		Dec.	229

Public Lighting—		Dec.	232
Report of Committee on Progress in Electric Lamps and Lighting Appliances—		Dec.	236
Fluorescence of Gems by Ultra-Violet Light—	W. J. Jones	Dec.	237
Public Lighting—	J. S. G. Thomas and D. Chandler	Dec.	247
The Lighting of St. Marie's Church, Rugby—		Dec.	250
International Studio		1922	
Mobile Painting—The Clavilux—	Roderick Seidenberg	March	84
Journal Chemical Society		1921	
The Decomposition of Ozone by Light of the Visible Spectrum—		Dec.	1948
The Action of Light of Short Wave-Lengths on some Organic Acids and their Salts—	F. M. Jaeger	Dec.	2070
Journal of Electricity and Western Industry		1922	
Adequate Highway Lighting as a Developer of Business—	Carl K. Chapin	Feb. 15	149
Journal of Franklin Institute			
Brightness of Light Sources—	W. E. Forsythe	Feb.	251
Radiation Equilibrium in an Opaque Uniformly Heated Solid and Duane's Hypothesis as to its Origin	A. G. Worthing	Feb.	252
Journal of Glass Technology		1921	
Helium Filled Electric Lamps—		Dec.	185
Decarbursing Tungsten and Like Metal—		Dec.	185
Licht und Lampe			
Die Beleuchtungstechnik im Jahre, 1921		Dec. 29	623
Buhnenbeleuchtung—		Dec. 29	625
Die Glimmlampen—		Dec. 29	630
Lighting Fixtures and Lighting		1922	
Design and Quality Keynote of Fixture Market—		Feb.	7
Moving Picture World			
How the Albany Movie Ball of the M. P. T. O. A. Was Illuminated—		Mar. 25	413

TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

VOL. XVII MAY, 1922 NO. 5

Proposed Standardization Of Colored Signal Lights

AMONG the many problems that have recently become important through the widespread use of automobiles and the resulting changes in traffic conditions, are those of the colored signal lights. It is obviously necessary that the public should be able to interpret correctly such signals, whether temporary or permanent, especially when used for the protection and control of traffic.

The variation in practice from one state to another, as well as the indescriminate use of red signal lights, are among the principal causes of confusion. Such confusion is liable to result in more or less inconvenience, and what is more serious; collision and other accidents. Since these conditions are developing rather rapidly, and in many cases are still in the formative state, it is quite apparent that it is desirable to effect a reasonable standardization as promptly as possible.

With these considerations in view, the Illuminating Engineering Society, through its Committee on Motor Vehicle Lighting, entered a request with the American Engineering Standards Committee for a conference to consider the desirability of effecting such a unification and to determine the desirable scope. Almost simultaneously and independently, the International Traffic Officers Association made a similar request. As a result of these applications, the American Engineering Standards Committee called a conference of all organizations understood to be interested in the questions.

The conference was held on May 23 in the Engineering Societies Building. The invited list included some thirty-seven different societies or groups. Among the organizations participating in the conference were the various steam and electric railway associations, automobile associations, gas and electric societies, safety organizations, Federal departments, including the Bureau of Standards, and representatives of state and municipal traffic organizations.

After some discussion, the conference recommended in favor of a national unification of all signals, approving an agenda which outlined in more or less detail, the scope of the standardization to be effected. The conference further requested the American Engineering Standards Committee to form a sectional committee for the purpose of preparing the standardization, and also requested them to designate the sponsor organization or organizations, and to take any necessary steps toward the formulation and promulgation of these standards.

The Illuminating Engineering Society was represented at the conference by Dr. Clayton H. Sharp and G. H. Stickney, as authorized delegates, while a number of other members were present, some of them delegates from other organizations. Dr. Sharp made the first presentation of the problem and indicated the obvious necessity of the proposed action. He further pointed out that, the Illuminating Engineering Society had no hard and fast program to promote, was not interested in any particular devices or practices, and only desired to secure a satisfactory set of practical standards which could be adopted throughout the country.

A. H. Rudd of the Pennsylvania Railroad, presented data showing the large number of railway crossing accidents resulting from the failure to observe signal warnings, and emphasized the necessity of not only arriving at intelligible standards, but also educating the public as to the meaning and importance of observing them.

Dr. M. G. Lloyd, representing the Bureau of Standards, presented a discussion with regard to the scope of the standardization, as did W. J. Serrill representing the American Gas Association, and several others.

In the discussions, it was recognized that there are certain standards, such as those employed in navigation and railway operation which were already established. It was pointed out that these could not well be changed, but that they should be considered in order to insure a unified system. While some difference of opinion was developed as to the desirability of changing the color of automobile tail lights, the conference in general, indicated a surprising agreement in all quarters. This, with the evident interest and activity of the American Engineering Standards Committee, seems to promise a prompt and satisfactory solution of these important problems.

G. H. STICKNEY.

The Membership Drive
Personal Solicitation Urged

IT IS VERY gratifying to find that the membership drive is accomplishing results, despite the fact that reports from other Engineering Societies show a marked falling off of new members, in comparison to other years, due without question to the necessity for business economics.

The number of newly elected members is within a very few of the total number elected during the entire preceding year. While the outlook is optomistic, only a final spurt as we enter the home stretch will bring us within reach of the goal set.

The writer is deeply indebted to the Committee who have done yeoman service and to the members at large who have lent their aid. It is his opinion however, that personal solicitation is the keynote to success and surely each member could devote a comparatively few moments to an avowed intention to obtain a new member.

With the present campaign of "More and Better Business" being pushed by the National Electric Light Association, there is a timely opportunity to preach the gospel of good lighting. It seems unnecessary to present to you the aims of the Society, or a statement of its splendid accomplishments, with both of which you are familiar.

In face of the great advancements made in illumination since the inception of the Illuminating Engineering Society, there is still much to be done. Lighting service, generally speaking, is below the standard of the appliance and power service, notwithstanding that its great potentialities far surpass either of them. It is only because of a lack of knowledge and appreciation of its great possibilities by the Public, and in general, the industry as well.

Every lighting man in the country should be a member of this Society, and the aims of the Society, namely to put lighting on a higher standard, should be uppermost in every member's mind.

Won't you do your bit and send us a new member? We will be glad to send you a blank application form on request.

G. BERTRAM REGAR, *Chairman,*
Committee on Membership.

REFLECTIONS

Massachusetts Issues Tentative Lighting Code

A TENTATIVE industrial lighting code has been issued by the Department of Labor and Industries of Massachusetts, with the object of permitting its experimental application by employers before a mandatory code is adopted. A public hearing on the code will be held at the State House in Boston on May 16, after which its definitive form will be determined.

The code in its tentative form contains nine rules, ranging from those of general requirements to classifications. A table giving the minimum amount of illumination to be maintained is published. The proper illumination for the various parts of a plant and various kinds of work is prescribed; methods of reducing glare are explained, and rules for the distribution of light to avoid sharp contrasts of intensity are given. Entrance and exit illumination, care of switches, maintenance of luminaires and the use of shades or diffusive glass are other points covered.

Industrial Lighting Code Proposed in the State of Washington

THERE IS now being drafted an industrial lighting code for the State of Washington by a committee of electrical workers, electrical contractors and the safety division of the State Department of Labor and Industries. When perfected the code will be submitted to the Department of Safety and a public hearing will be held. At present the inspectors can only recommend the installation of proper lighting equipment. The plan is not to add expense by forcing employers to install new luminaires, but rather to provide a standard for future installations. The code will embrace not only yard and factory lighting but also the proper arrangement of skylights and windows. Day Morgan, electrical engineer, who has had experience in drafting lighting codes in other states, has been engaged to gather data and draft the code with the assistance of Mr. Meechem, electrical contractor of Seattle; F. G. Heller of the electrical workers and J. H. Lewis, electrical inspector for the Department of Labor and Industries.

A New Tungsten Arc Lamp

A NEW TYPE of tungsten arc lamp giving virtually a point source of light has been developed recently by the Philips Glowlamp Works of Enidhoven, Holland, the smaller sizes of which are now ready for the market. It is a lamp particularly adapted for projection, microscopy and general laboratory use.

In this lamp, for which patents have been asked, an arc discharge takes place between two small tungsten spheres in an atmosphere of a rare gas. In order to insure the striking of the arc a third electrode is mounted in the terminal glass midway between the feed wires. This electrode is connected through a high resistance to one of the lead-in wires. The material and form of this third electrode have been chosen in such a way that a glow discharge sets in first between it and the electrode next to it, thus starting the discharge between the spheres.

The distance between the spheres and the glass wall may be very small, 2.0 cm. to 2.5 cm., so that an optical condenser with a short focal distance can be used where the lamp is applied to projection purposes. A funnel-shaped screen is provided, on which the evaporated and sputtered tungsten is deposited in order to prevent the blackening of the bulb. The lamp has the advantage, it is claimed, that it can be run on a 220-volt alternating current circuit, and except for a series resistance, no auxiliary apparatus is necessary.

Cold Light

PURELY from a scientific standpoint the cold light discoveries of Professor E. Newton Harvey, of Princeton University, are of great importance. Whether an immediate practical application of the knowledge he has gained is likely at this time is problematical and unimportant.

He has demonstrated that cold light is possible, and is prepared to demonstrate that he has found a way to make luciferin, the light-giving protean substance of animal origin, continue to glow for a long period. His aim now, and the aim of all scientists similarly interested, is to produce luciferin by artificial means. When they can do this human civilization soon will find a way to accomplish what lighting bugs have always done. . . . .
—Editorial, *New York Tribune,* April 24, 1922.

PAPERS

BETTER SIGNS*

BY C. A. ATHERTON**

Synopsis: The development of one of the major forms of display lighting, electric signs, has progressed to a point where there is a need for a more exact engineering basis of design and a more artistic treatment in general. This is evidenced by the growing interest of building architects some of whom are including the design of the sign in the building plans in an effort to improve especially the daytime appearance of the signs. Because of the adoption during the last two years of higher wattage lamps for electric signs, it has also become necessary to determine the relative size of the spot of light obtained from lamps of different wattages when used in electric exposed lamp displays, in order to predetermine the exact pattern of the appearance of the sign when seen at night. An equation has been developed by means of which this spot size can be determined for various conditions. A modification of the same equation is also given which may be used for the determination of the maximum distance at which Gothic letters, (which are those most commonly used in electric signs) may be read under normal conditions. Through another adaptation of the equation, lamp spacing for the various wattages is determined for various types of signs. An analysis is made of the more common forms of motion which together with brightness is the principal differentiating characteristic of electric as contrasted with other forms of advertising. Proper illumination of enclosed lamp signs is discussed and a simple rule formulated for obtaining satisfactory results. The need for maintenance of electric signs is emphasized by the record of the improvement in average and uniformity of brightness of an enclosed lamp sign which was cleaned and put into proper shape.

There are several reasons why we may expect in the next few years an increasing use of electric sign advertising. In the first place, business conditions have changed. Whereas during recent years, a large share of advertising was done to maintain good will, and to maintain a position already secured; to-day in the strong buyers' market and probably for the next few years advertising will have to create sales, its function will have to be active. Business conditions are somewhat as they were in the last years preceding the war, which were also the last years of active electric sign development. In the second place the growing popularity of large motion picture houses, and the more limited incomes of buyers and the larger proportion of automobile owners, all react to bring more and more people into the city and town centers for relaxation in the evening. It is absolutely certain that just

* A paper presented before the Cleveland Chapter of the Illuminating Engineering Society, March [illegible], 1922.

** Engineering Department, National Lamp Works of General Electric Co., Cleveland, O.

so long as people gather for the least preoccupied moments of their day, and in the receptive mood of the evening hours, advertisers will capitalize the golden opportunity. There will always be outdoor night advertising and though the nature of it may change, it will probably be largely some form of electric sign advertising.

In this industry as in all others in which there are commercial and social reasons for existence, the first law is that of constant evolution, of improvement. The industry, in its forty years of existence has grown and changed very greatly. Many architects still look upon signs largely as a sort of fungus, an ugly parasitic growth upon the beautiful buildings they have been at such pains to erect. To most of them, electric signs are an avoidable evil and they have as little to do with them as possible, approving the least ugly of the submitted designs if they are asked to pass upon them at all. A few prominent architects however have accepted the inevitability of a sign on the building and are including a sketch of it in the building plans just as they include the marquee and to a much lesser extent building front display lighting.

INTEREST SHOWN BY ARCHITECTS

A few typical examples of some of the more exceptional work that has been done in display and sign lighting will illustrate the trend and possibility of improvement which may be effected by having the design of the sign or display lighting either a part of or in keeping with the design of the building. In Figure 1 a form of display lighting is shown which has been built into the building front. The lamps are hidden and so do not detract from the daytime appearance of the building, as shown in Figure 2, and the night-time effect is very fine and dignified. This form of decorative lighting although it is not strictly in the class of signs, is a form of electrical advertising. It has been used very little. I believe, however, that the excellent effects obtainable should be a guarantee of its popularity if an effort can be made to acquaint people with its possibilities and architects with the fact that it may prevent the subsequent addition of less harmonious displays. In Figure 3 an excellent example of exposed lamp outline lighting is given. The theatre is one of the more

Fig. 1.—An effective form of building front display lighting used in the Denver, Col., Gas and Electric Light Co.

Fig. 2.—Denver Gas and Electric Building by daylight. Mr. F. F. Edbrook, Architect.

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Fig. 3.—One of the best examples of building outline lighting of the more spectacular type. The architecture is especially designed to accommodate the display.

Fig. 4.—It is possible to remove the "tin box" look on small signs by the careful use of decorations.

popular motion picture houses, the whole building motif is one of brilliance and spectacular sensationalism. Here is found no attempt at the classic architecture evident in the case of the Music Box (Figure 6) for instance. The outline lighting, which of course is an integral part of the building itself, is quite in keeping with the rest of the building decoration and as such is excellent. In Figures 4, 5 and 6, three examples of theatre signs are shown. The two buildings were designed by the same architect. The signs stand out as excellent examples in theatre sign design. It should be noted especially that the sign and building architecture are harmonious, both are dignified and the sign instead of detracting from the building appearance in the daytime is complementary and an addition to it.

DAYTIME APPEARANCE

One of the chief criticisms of signs as many are made to-day is that their daytime appearance is not good. To obtain a spectacular effect at night, the daytime appearance of the building front and roof are often somewhat sacrificed. The mechanical structure of the sign, the minimum depth of which is limited by the size of the lamp receptacle, and the frame work in which the electrical connections are hidden are large as compared with the over-all size of building front signs and so task the designer severely to make his sign have a daytime appearance which is not heavy and box-like. This difficulty, however, automatically disappears when the sign is made large. Large signs do not appear heavy or bulky. They do suffer in some cases from another and perhaps diametrically opposite effect. When there is anything directly behind them, and especially when there are two signs back to back, the daytime appearance is one of great confusion. Only when the sun is shining directly on white painted letter faces and the more or less distant background is comparitively dark will the sign stand out clearly, and will the frame work and backs of the other letters and the other nearby objects not interfere seriously with the effectiveness of the sign. In Figure 7, one of the most beautiful of Cleveland's signs by night is shown as it appears on a dull day. The back of the letters facing in the other direction are so prominent that it is difficult to read the

letters facing the camera. It may be that the science of camouflage, used so extensively by the Navy during the War, or perhaps some form of screen with which to break up the lines of the backs of the opposite letters without interposing too great an area to wind pressure would diminish this bad effect.

The bulky, unfinished appearance of small signs can be largely overcome by a careful use of ornamentation. Figures 4, 5 and 6, especially those of the Music Box and Roosevelt Theatre, illustrate the fact that signs for which the building architect is responsible have the appearance of being less crude, heavy, and box-like than the ordinary design. The increasing interest of architects will do much to improve electric signs, to make the general design more consistent with the building architecture and to make them appear less as they so often do now, as separate and incongruous after-thoughts.

NIGHT APPEARANCE

The development in the future leading toward the improvement of the night appearance of signs may take one of two forms. New elements and new principles may be applied to supplement the old ones, or what is more likely, the elements and the principles of the past may be used in more effective ways. The elements now available must be used more carefully and with a greater knowledge of what their effects will be.

With the elements now available, the variables with which the sign designer and advertiser work are:

1. Pattern; including size, shape, wording, and picture presented.

2. Brightness; dependent upon the size of the lamps and the closeness with which they are spaced.

3. Color; which is obtained by use of glass color caps, by dips or sprays, or by the use of natural colored glass lamps.

4. Motion; obtained by means of a flasher, dimming device or control mechanism.

THE PATTERN

Of these four variables, the first allows the designer the greatest latitude; it is the least susceptible to engineering analyses and formulae. It is in the creation and selection of the pattern

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Fig. 5.—The signs carry out the architecture of the building and by the use of castings and ornamented supports are made to be just as attractive as the fine building front. The architect was Mr. C. Howard Crane of Detroit, Mich., for this and the Music Box Theatre.

Fig. 6.—An excellent example of the use of ornamentation in giving a sign "finish" and making it conform to the building architecture. Attention is directed especially to the sign at the left.

that the designer must show his genius, his thorough understanding of the psychology of advertising and of his clientele. The pattern may consist, of course, of lettering or of a picture, or of a combination of the two. A picture has great attracting power, this makes the picture sign especially valuable when there are many other signs with lettering only in the field of vision. But of even greater value is the high selling power which a picture possesses, the capacity to impress the message and make it permanent in the memory of those who have read it. As competition becomes keener, methods of greater attracting and selling power are needed. Even after a sign has caught the eye of the passerby, and after he has been able to read it, unless the sign has selling power the message will not be remembered. It will be forgotten as soon as another bright sign comes into sight. To effectively sell the message, picture signs are very valuable. For this reason I believe electric signs of the future like other advertising will have to resort to more pictures and more beautiful picture portrayals.

There will probably also be a continuously greater demand for a more flexible construction to permit of a change of display more often. Most large signs are so constructed now that only the supporting framework remains standing when the display is changed. The lettering or picture is built and attached as a unit or as units to this framework and it is nearly as expensive to erect an entirely new sign as it is to change the pattern of an old one. It is not difficult to think of a construction whereby the pattern could be readily changed each week. For districts where very much the same people pass before the sign week after week, every sign, no matter how fine its pattern, must lose much of its effectiveness, by becoming just another part of the familiar old skyline. A changeable sign is, of course, more expensive, both in construction and maintenance but is also more valuable and in certain places its value certainly outweighs its cost.

SIGN PICTURES MUST BE SIMPLE

Electric sign advertising differs somewhat from printed advertising. In an electric sign, the intricate detail of a Parrish picture, for instance, is nearly if not quite impossible. The most successful signs are exceedingly simple or if they are elaborate, they

are also very large. Artists painting on canvas employ as one of their chief means of getting certain effects, lines of varying width. Some pictures on canvas are painted with fine lines and show intricate detail. In others there are a few bold, heavy strokes only. These pictures are impressionistic, or suggestive. We all know that successful sign pictures and lettering are of this latter class. The strokes are bold and simple. The effects are obtained largely by suggestion. Whenever a sign artist attempts to present very fine detail, the contour of the separate lines is lost. The picture is a mass of light only.

It is not enough, however, merely to say that the strokes must be simple and heavy. If sign design is to be advanced to higher levels, it is necessary to know just how heavy, or just how simple the strokes have to be lest they become confused.

WIDTH OF LINE OF LIGHT

We know that whenever we look at any object which is bright in contrast to surroundings, it appears to be larger than it really is; this phenomenon is called irradiation, the apparent enlargement takes place in the eye. The rays of light from a bright object act just the same as those from dark objects until they get into the eye and then they spread out or else the impression from them does. So that when we look at a sign lamp, we do not see the bright filament in its true size. We see a spot of light whose apparent size is much larger than the filament.

The effect of irradiation as it applies to sign design may be observed very simply. If a bare incandescent lamp is mounted in a dark place and the observer walks away from it watching the filament all the while, the filament will appear first approximately in its actual size and shape. As the distance of observation increases, the filament parts seem to coalesce into a ball of light which increases in size until it entirely fills the ring of the bulb and then keeps on expanding, always apparently larger.

If two lamps are observed one after the other, the one of higher intensity will appear of any given size at a shorter distance than will the one of lower intensity. But if the room in which the test is made is not quite so dark, the distance at which the spot will appear of any given size will be greater than at which it would appear of the same size in the darker room.

There are several other things which affect the apparent size of the spot of light such as the color of the light, and the density of the atmosphere, etc., but these play a less important part and have to be considered by themselves.

In laying out the pattern of an exposed lamp sign, therefore, the brightness of the lamps must be taken into consideration. All good sign designers do this anyway. They have designed many signs and watched them after they were put up and they know just about how fine a line they can safely draw and be sure that it will be distinguished from its neighbors. But occasionally a sign is built and erected and the effect is not what was wanted. Perhaps one of the reasons why designers so seldom attempt much of anything except lettering and the simplest of outlines is because they do not know just how far they can go with intricacy of pattern and be sure of clearness.

IRRADIATION EQUATION

In a series of tests, the apparent size of the spots of light from different sizes of lamps under different conditions was measured, from which a mathematical equation was developed, by means of which the apparent size of the spot of light from any lamp when viewed at any distance through clear air may be calculated. The equation is:

$$S = \frac{D}{AB + 0.0083D} + 0.0035D \qquad (1)$$

in which, "S" is the diameter measured in inches of the apparent size of spot of light; "D" is the distance to the observer measured in feet; "A" and "B" are constants which depend upon the size of the lamp and the background brightness.

TIP CANDLEPOWER

A clearer visualization of the meaning of this equation may be had from three curves. In Figure 8, the variation in the apparent size of the spot of light from a hypothetical lamp whose tip candlepower is changing is shown. The distance at which it is assumed that we see this lamp is 1,000 feet and it is set in a dark field with clear atmospheric conditions, and there are no other lights visible. As the candlepower of the lamp increases, (without any great change in color), the spot of light will apparently increase according to this curve.

DISTANCE

In Figure 9, the effect of viewing a lamp at various distances is shown. In this curve a 75-watt lamp is observed through the tip, there are no other lights visible, and the atmosphere is clear; as the distance increases from the lamp to the observer, the experimenter who is standing beside the lamp is measuring the spot which is seen. In the equation, "S" varies as the first power of "D" plus another smaller function of "D." In electric sign design this variation is of the greatest importance.

BACKGROUND BRIGHTNESS

In Figure 10 is shown the effect of increasing the background brightness, in this case, the same 75-watt lamp is used. The observers are standing 1,000 feet away from the lamp and lights of various sizes and at various angles from the observed light are being turned on. A secondary lamp located near the light source which is being observed reduces the apparent size of the spot of light more than the same secondary lamp would if located farther away. In fact all of the light which enters the eye has an effect of increasing the general surrounding illumination, and so reducing the apparent size of the spot of light which is being measured.

In the spot size equation, the only term which is not easy to determine is "B," which depends upon the background brightness. In Table I the more commonly found limits of this term (as applied to electric signs) are given. After a little experience it is easy to estimate values of "B" for any given condition. The brighter the district and the more lamps there are in the sign, the larger is the constant, "B."

TABLE I.—VALUES OF CONSTANTS FOR CANDLEPOWER AND BACKGROUND BRIGHTNESS

Lamp size (clear glass)	Tip candlepower		Dark districts Small signs 100 lamps		Bright districts Large signs 2000 lamps	
Watts	Value	A	B	AB	B	AB
10	2	34	3	102	20	680
25	18	18	5	90	35	630
50	43	14	5	70	35	490
75	81	12	5	60	35	420
100	120	10	5	50	35	350

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Night appearance

Daytime appearance

Fig. 7.—An improved daytime appearance of large roof signs is one of the problems of the sign designer.

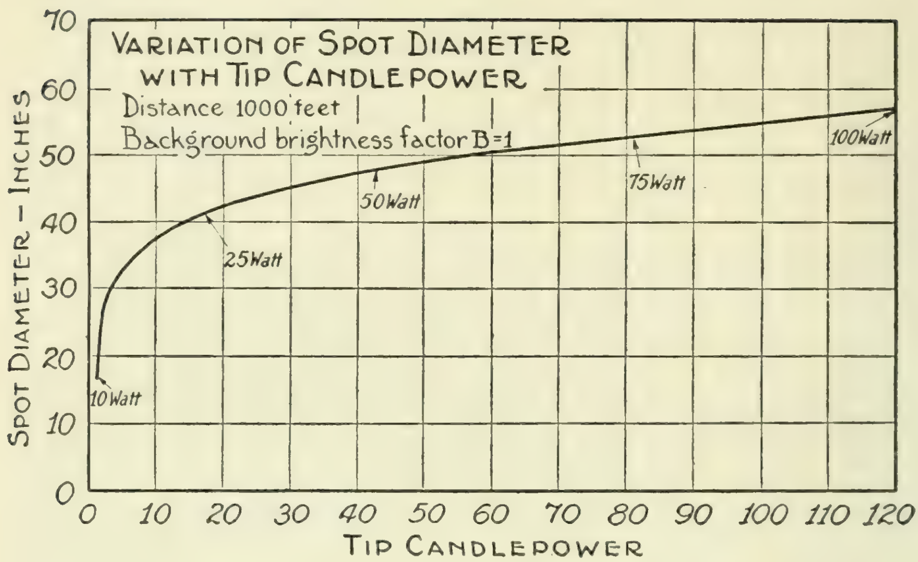

Fig. 8.—The apparent size of the spot of light from a bare lamp with other conditions constant increases with the candlepower of the lamp.

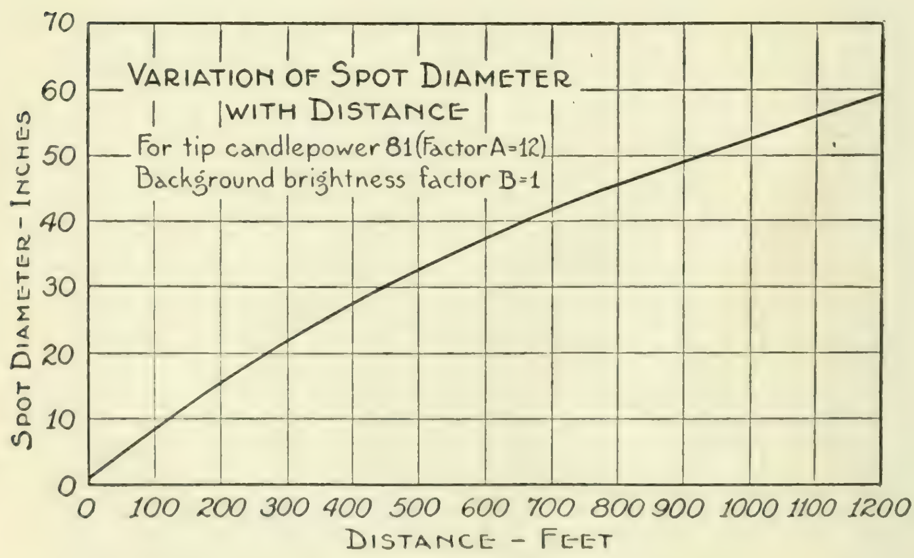

Fig. 9.—For exposed lamp sign design, it is very important to know that the greater the distance from which a sign is to be seen, the larger will the spots of lights from the lamps appear.

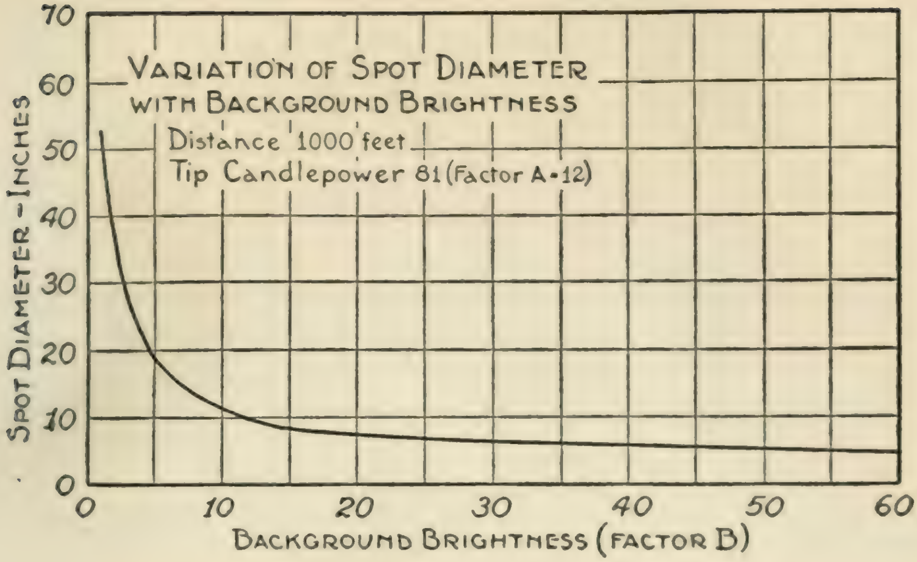

Fig. 10.—Every ray of outside light reaching the eye reduces the apparent size of the spot of light from any particular lamp.

PATTERN LAYOUT

There are many ways in which the irradiation equation can be of use. The most natural application is in the layout of the pattern for the sign. For instance, let us assume that a certain picture, such as Figure 11, has formed the central figure for years in some particular publicity and it is desired to put it into an electric sign. There is no intricate detail in this picture. It is ideally suited to adaption for an electric sign. Let us assume that a location is selected such that the sign must be clear and effective from 200 to 1,000 feet, and that, because of the many other signs about, it is decided to use 75-watt gas-filled lamps. The most difficult position from which to decipher the sign and therefore the one which determines its size is the greatest distance at which it must be clearly legible, in this case 1,000 feet. By means of the equation we can calculate the size of the spot of light from each lamp at this distance. This determines the width of the lines of light of which the pattern must be composed, and so determines the minimum size of the sign. In order to keep the cost of the sign low, a line as wide as possible is used and

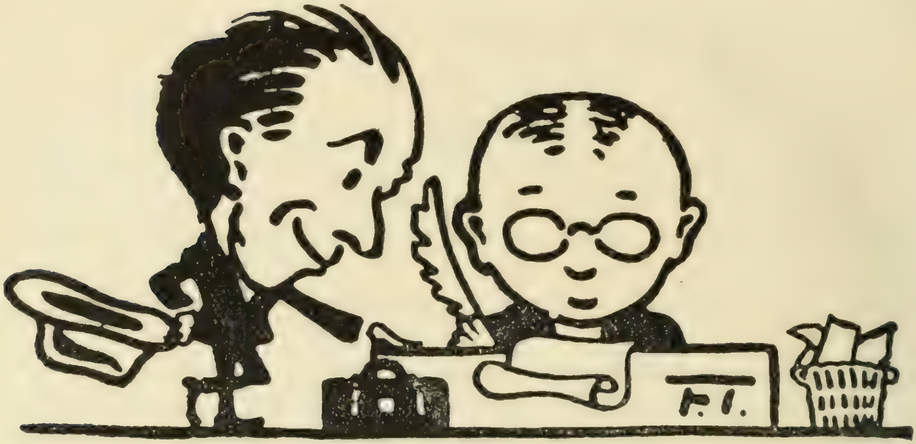

Fig. 11.—It is assumed that this picture is the central feature of some publicity program and that it is desired to reproduce it in an electric sign.

when the pattern is covered with spots proportional to the calculated size it appears as in Figure 12. If the designer is satisfied with this, the problem is ended. But perhaps he is not satisfied; the picture could be brought out more clearly. The features are a little indistinct and it is decided, let us say, to pay a little more in order to secure better detail at this limiting distance. At shorter distances of course the spots would be smaller and the pattern more distinct.

VALUE OF A CHARACTERISTIC BORDER

There may be several ways to obtain the better detail at the greater distance: a change in the picture; an increase in the size of the sign and the pattern; the use of colored light; or by the use of smaller lamps in the picture to get the detail a little better and the use of the high wattage lamps in a border to retain the greater attracting and selling power. The bright border will play three parts. Not only will it attract attention by its mass of bright lights, but it will raise the brightness of the surroundings which will reduce the apparent width of the lines of light of the smaller lamps, and so will make it possible to obtain even greater fineness of detail, and it will give the sign an over-all characteristic shape. These are all very valuable features but none more so than the third. If this sign is to command a view beyond the limit of its ordinary legibility, say a mile or more, it will stand out from the maze of other signs and lights up to

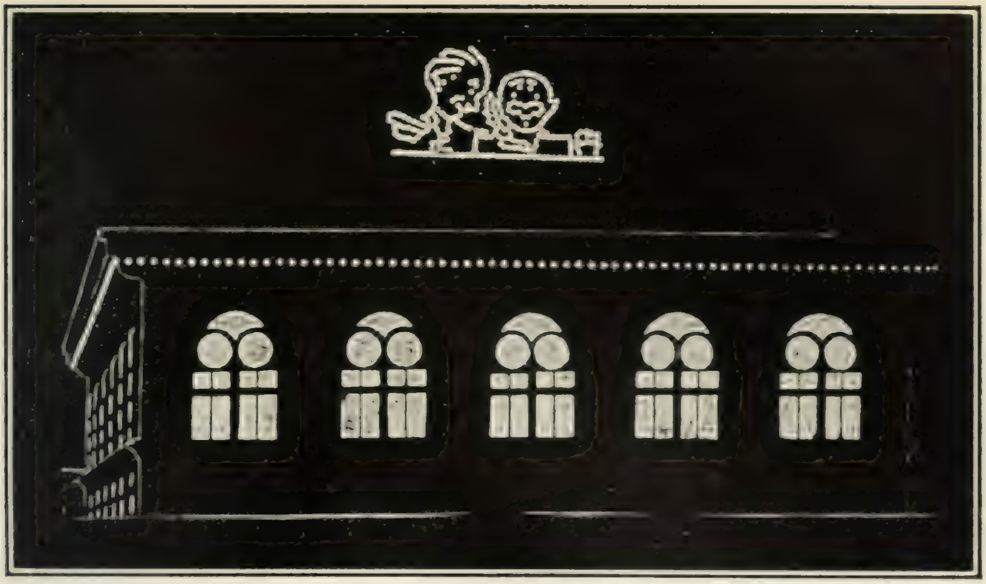

Fig. 12.—The publicity pattern if represented with 75-watt gas-filled lamps would appear like this at 1,000 feet. It is good but the details are not quite clear enough.

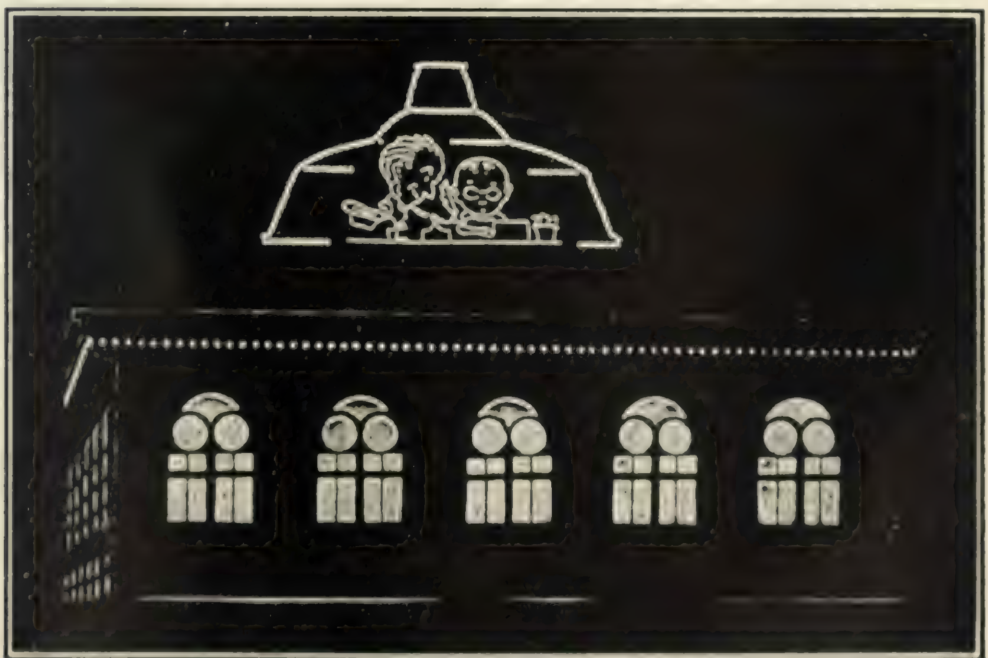

Fig. 13.—By using 25-watt vacuum (coil filament) lamps in the picture and 75-watt gas-filled lamps in a border of characteristic shape, the details can be brought out more clearly and the effectiveness of the sign increased very greatly.

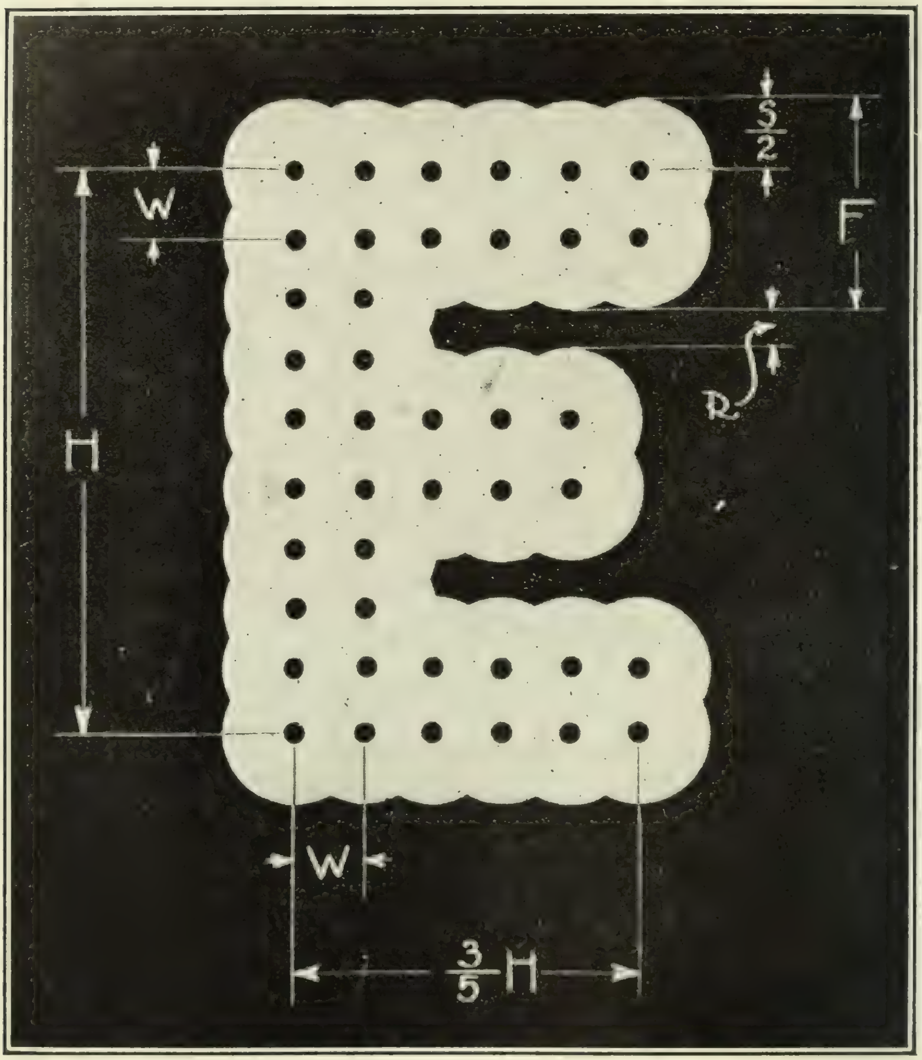

Fig. 14.—The legibility equation is based upon a Gothic letter "E," whose dimensions are as shown. When a single line of lamps is used, W = o.

distances many times the limit of legibility because of its characteristic over-all shape. This is particularly true when the shape used is one well known in the other forms of advertising of the same article. The area of its effectiveness may in this way be increased enormously.

But to come back to our specific design let us assume that it was decided to use 25-watt clear glass lamps in the picture, and 75-watt lamps in a border to obtain better detail in the picture itself. Although this will make the outside shape of the sign more prominent than that of the picture, a reverse effect can be obtained by alternating with the picture, words using 75-watt daylight lamps in them and also if desirable by dimming the border lamps at the same time.

The sign pattern with 25-watt lamps in the picture and 75-watt lamps in the border would appear at 1,000 feet as shown in Figure 13. At shorter distances, of course, the lines of light would be apparently thinner and the pattern would be still clearer.

LETTERING

To make lettering legible at any given distance, the same process may be used. Because however Gothic letters are nearly always used in large electric signs, it is possible to simplify the calculations by modifying the equation. For convenience, the most used letter in the English language, a letter "E," whose width in Gothic form is three-fifths of its height, is taken as a base and the legibility of other letters is referred to it.

For the Gothic letter "E," the maximum legibility distance "D_m" in clear atmosphere (with average eye sight) may be obtained from equation (2)

$$H = 3W + \frac{2\ D_m}{AB + 0.0083\ D_m} + 0.01\ D_m \qquad (2)$$

in which:

"H" is the letter height, (Figure 14) measured on the center lines of the outside rows of lamps.

"W" is the letter stroke (Figure 14) also measured on the center lines of the outside rows of lamps, and in the case of a single line of lamps is equal to zero.

"D_m" is the greatest distance at which the Gothic letter "E" can be read.

"A" and "B" are the lamp and background constants from Table I.

The relative legibility of Gothic letters of the same height and good proportions is as follows:

TABLE II.

A–1.30	H–0.92	O–1.06	V–1.08
B–0.85	I–1.41	P–1.04	W–1.13
C–1.07	J–1.21	Q–1.06	X–1.08
D–1.03	K–1.06	R–0.97	Y–1.04
E–1.00	L–1.19	S–0.95	Z–1.01
F–1.04	M–1.13	T–1.15	
G–0.92	N–1.00	U–1.07	

LAMP SPACING

Another application of equation (1) and one that can probably be used more often, comes in the determination of the proper spacing of lamps. Just as the greatest distance at which a sign must be legible determines the size of the sign and of the letters and figures in the sign, the shortest distance at which the sign must have a good appearance determines the lamp spacing. What constitutes good appearance is, in this matter as in most others, merely an expression of personal preference. In the picture of the salesman bringing in his big order the spacing was made such that the spots of light would appear to be just tangent. For people viewing that sign at 1,000 feet, the sockets would have been spaced to obtain this effect for the 75-watt lamps 8.5 inches apart and for the 25-watt lamps, 5.5 inches apart, the diameters of the respective spots. The actual spacing for the sockets for that sign as for any other sign would have to depend not upon the greatest but upon the shortest distance at which the appearance of continuity of light is wanted.

If we accept this condition, that is the spots of light apparently just tangent, as the best compromise between increasing cost and improving appearance, we have a basis of calculation for proper lamp spacing. Because of the mechanical size of the lamp bulbs and of the sockets, it is not usually feasible to space lamps more closely than 3 or 3.5 inches. From the equation it will be seen that lamp spacing to meet this condition of continuity of the line of light depends principally upon the viewing distance. Contrary to popular opinion, as evidenced by common practice, it is entirely

independent of the size of the letter or of the picture; it varies only slightly with the total size of the sign but to a greater extent with the background brightness and the size of the lamp. To give an idea of the order of these spacing distances, a few typical examples have been worked out and are shown in Table III.

TABLE III.—LAMP SPACING FOR EXPOSED LAMP SIGNS TO OBTAIN THE APPEARANCE OF A CONTINUOUS LINE OF LIGHT, WHEN THE SIGN IS SEEN THROUGH CLEAR AIR AT VARIOUS DISTANCES

Clear glass lamp	Distances to observer in feet — When the surrounding illumination is									
	Comparatively bright					Comparatively dark				
Spacing Inches	10 watt lamps	25 watt lamps	50 watt lamps	75 watt lamps	100 watt lamps	10 watt lamps	25 watt lamps	50 watt lamps	75 watt lamps	100 watt lamps
	*	*	*	*	*	*	*	*	*	*
3	480	420	*	*	*	290	*	*	*	*
4	630	560	500	*	*	390	330	*	*	*
5	790	700	620	570	*	490	410	*	*	*
6	950	840	740	680	610	590	500	420	*	*
7	–	990	870	800	720	690	580	490	440	*
8	–	–	990	910	820	790	660	560	500	*
9	–	–	–	–	920	880	740	630	570	500
10	–	–	–	–	–	980	830	700	630	550
11	–	–	–	–	–	–	910	770	690	610
12	–	–	–	–	–	–	990	840	750	660
13	–	–	–	–	–	–	–	900	810	720
14	–	–	–	–	–	–	–	970	870	770
15	–	–	–	–	–	–	–	–	940	830
16	–	–	–	–	–	–	–	–	1000	990

* For distances less than the lowest given in the table, it is impossible to obtain the appearance of a continuous line of light. If the exposed lamp design is used for signs in such locations, the spacing should be made as short as mechanically possible.

From Table III it is possible to determine lamp spacing to obtain any effect that is desired for any of the lamps included in the table at any distance up to 1,000 feet. Only two conditions of surrounding street illumination are given. But from these two, intermediate and extreme condition spacing can be easily estimated. A large sign has the same effect as increasing the street illumination and so if the sign is exceptionally large, the brighter background conditions will hold even though the actual surrounding street illumination is not very high, etc.

Spacing is not shown for distances greater than 1,000 feet because very few signs are ever so located that the shortest distance at which they are often seen is greater than 1,000 feet. The

governing distance upon which the lamp spacing should be based is, of course, the shortest distance from which the sign may at any time be seen by any number of people. The shorter distances for the larger lamps are also omitted because the effect of high power lamps at very short distances is not good.

Probably the most striking fact brought out by the table is that it is impossible to make an exposed lamp sign using small lamps for distances less than 290 feet if the requirement that the appearance of a continuous line of light is adhered to. If, for any reason, it is desired to have a sign in which there is a space between the spots of light, equal in size, let us say, to the diameter of the spots, the spacing used should be approximately double or the distance approximately half the spacing or the distance given in the table. While nearly everyone will probably agree that a continuous line of light is desirable in an exposed lamp sign, there are times when because of cost the closer lamp spacing will not be used. In Figures 15 and 16 the exact meaning of a continuous line of light and of a spotted effect are shown.

There are also many locations in the brighter street where signs are always seen at distances too short to obtain a continuous line of light and where enclosed lamp signs with translucent letters cannot be used because of brighter competing signs, or because the letters or patterns are too large to be made in glass. For such installations, the lamp spacing should, of course, be as close as possible, which is ordinarily about 3 inches. This applies to all locations which are marked with an asterisk in Table III.

BRIGHTNESS

Near the beginning of this paper, there were mentioned four variables by means of which designers can increase the attracting and selling power of electric signs. When a new sign is erected, it must compete with the other signs about it. We have already considered some aspects of pattern and of the brightness of the lamps as it affected the pattern. We found that many things could be done to increase the attracting and selling power of the pattern; the sign could be made larger or the picture more striking, or it could be made brighter.

The brightness of the lamps is a very important factor. In general the attracting power of a sign increases directly with its

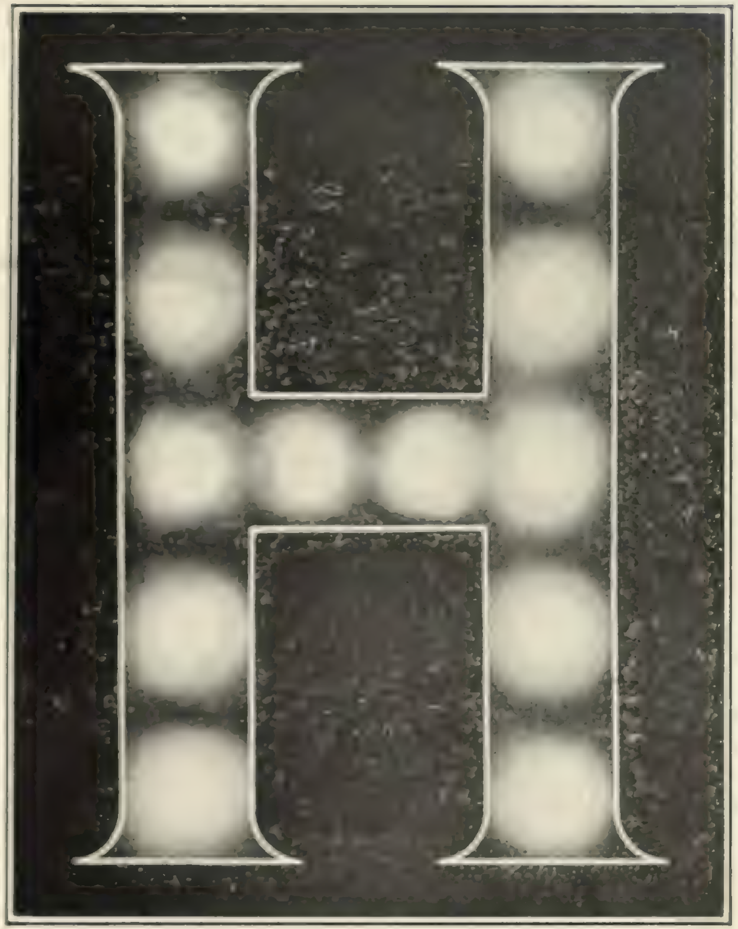

Fig. 15.—When lamps are spaced at distances greater than the spot diameter, the letter appears spotted.

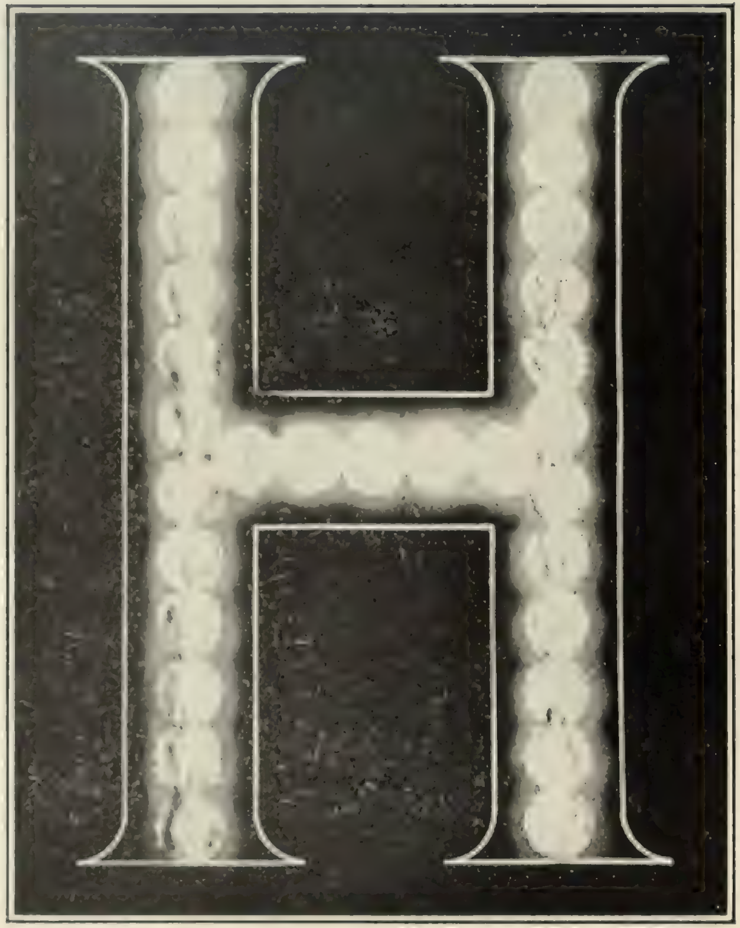

Fig. 16.—When the lamps are spaced at a distance equal to the spot diameter, the line of light is continuous. The letter is formed entirely of light and is outlined only by the reflected light on the letter face and trough sides.

TABLE IV.—Sign and Display Lighting Lamp Applications

Lamp					Applications																				
	Watts	Volt	Bulb	Finish	Surrounding Illumination																				
					Dark							Medium							Bright						
					Exposed lamp signs — Minimum viewing distance Feet			Enclosed lamp opal glass signs	Building outline lighting		Marquees	Exposed lamp signs — Minimum viewing distance Feet			Enclosed lamp opal glass signs	Building outline lighting		Marquees	Exposed lamp signs — Minimum viewing distance Feet			Enclosed lamp opal glass signs	Building outline lighting		Marquees
					10–25	25–75	75 and up		Up to 25 ft.	Over 25 ft.		10–25	25–75	75 and up		Up to 25 ft.	Over 25 ft.		10–25	25–75	75 and up		Up to 25 ft.	Over 25 ft.	
Vacuum type	5	11–12½	S–14	Clear	C	C	B	E	D	D	E	D	D	C	E	E	E	E	E	E	E	E	E	E	E
					b	b	b	e	c	c	d	c	c	b	e	d	d	e	d	d	c	e	e	e	e
	5	55–65	S–14	Clear	B	B	B	E	C	D	E	C	C	C	E	D	E	E	D	D	D	E	E	E	E
					a	a	a	e	b	c	c	b	b	b	e	c	c	d	c	c	c	e	d	d	e
	10	110–120	S–14	Clear	A	A	B	E	B	C	D	A	B	B	E	C	D	D	B	B	C	E	D	E	E
					b	b	a	e	a	b	b	a	a	a	e	b	c	c	a	b	b	e	c	d	d
	25	110–120	P–19	Clear	C	C	B	A	B	A	B	B	B	A	C	A	B	B	B	A	B	D	B	C	C
					c	c	c	a	c	b	c	c	c	b	b	b	a	a	c	b	a	c	b	b	c
	25	110–120	P–19	Blue	C	C	B	A	B	A	B	B	B	A	C	A	B	B	B	A	B	D	B	C	C
					c	c	c	a	c	b	c	c	c	b	b	b	a	a	c	b	a	c	b	b	c
	25	110–120	P–19	Diffusing	B	C	C	B	B	B	A	B	B	C	D	A	C	B	A	B	C	E	A	B	C
					c	c	d	b	c	c	b	c	c	d	c	b	b	a	b	c	b	d	a	b	c
	50	110–120	P–19	Clear	E	E	C	B	C	B	C	C	C	B	A	C	A	B	C	B	A	C	C	B	C
					e	e	d	c	d	d	d	d	d	c	a	d	c	c	d	c	b	b	c	a	b
	50	110–120	P–19	Blue	E	E	C	B	C	B	C	C	C	B	A	C	A	B	C	B	A	C	C	B	C
					e	e	d	c	d	d	d	d	d	c	a	d	c	c	d	c	b	b	c	a	b
	50	110–120	P–19	Diffusing	D	D	D	C	C	B	B	B	B	C	B	B	B	A	A	B	B	D	A	C	B
					d	d	d	d	d	d	c	c	c	c	b	c	c	b	b	c	c	b	b	b	a
Gas-filled type*	50	110–120	PS–20	Clear	E	E	C	B	D	C	C	D	D	B	A	C	A	B	C	B	A	B	C	B	C
					e	e	d	c	d	d	d	c	c	c	a	d	c	c	d	c	b	a	d	a	b
	50	110–120	PS–20	Daylight	E	E	C	B	D	C	C	D	D	B	A	C	A	B	C	B	A	B	C	B	C
					e	e	d	c	d	d	d	c	c	c	a	d	c	c	d	c	b	a	d	a	b
	50	110–120	PS–20	White	D	D	C	C	C	C	B	B	B	C	B	B	B	A	A	B	B	C	A	C	B
					d	d	d	d	d	d	c	c	c	d	b	c	c	b	b	c	c	b	b	b	a
	75	110–120	PS–22	Clear	E	E	D	C	E	D	D	D	D	C	C	D	B	C	D	C	A	A	D	A	B
					e	e	d	d	e	d	e	e	e	d	d	e	c	d	e	d	c	b	e	b	c
	75	110–120	PS–22	Daylight	E	E	D	C	E	D	D	D	D	C	C	D	B	C	D	C	A	A	D	A	B
					e	e	d	d	e	d	e	e	e	d	d	e	c	d	e	d	c	b	e	b	c
	75	110–120	PS–22	White	E	E	D	D	E	D	C	C	C	D	D	C	C	B	C	B	B	B	B	B	A
					e	e	d	d	e	d	d	d	d	e	e	d	c	c	d	c	d	c	c	c	b

Upper case letters are for districts of relatively large circulation.

Lower case letters are for districts of relatively small circulation.

* Gas-filled lamps when exposed to the weather should be equipped with protective caps.

brightness. Especially is this the case in locations where the sign has to compete with many other signs. An ideal condition of brightness for any sign obtains, therefore, when it is just bright enough so that by this feature alone it is the first sign to catch the eye. To make the sign brighter than this would be to add to its cost and gain nothing as far as attracting power goes. On the other hand, if the circulation of the sign is large, it may pay to make the sign brighter than it need be to have high attracting power in order also to increase its selling power. Because it is so difficult to evaluate all of the factors, for each individual sign a list of proper lamp applications based upon good practice has been drawn up which may be consulted in selecting lamps. The greatest weight is given to the design which will have good attracting power; the selling power and cost of maintenance are also weighed. The letters in Table IV means:

A—Best installation.

B—Good installation.

C—Less desirable installation.

D—An installation so dim as to have very low attracting power, or so bright as to have very low legibility or the cost of the brightness of which is out of proportion to the value of the sign.

E—Quite poor.

The upper case letters indicate the application value for relatively high circulation for the given district. The lower case letters indicate application values for relatively low circulation.

COLOR

In spite of the fact that colors have been used almost since the time of the first sign, and a few very fine colored effects have been obtained, we probably know less about the application of color in exposed lamp electric signs than we do about any other phase. We know that a red light stands out strikingly, that green light is cool and soothing, etc. We know that a little color in a sign increases its effectiveness enormously and none of us likes too much color or colors which do not harmonize or which make the sign splochy and cheap. We know that colored lights fade and blend as the distance increases so that usually colored light signs are more effective at shorter distances and we know

that more and more colored light is going to be used in electric signs in the future. This is another of the great problems upon which electric sign designers are at work upon and for which the possibilities seem limitless to-day.

THREE KINDS OF MOTION

Motion presents an endless realm of possibilities. Applied to electric signs, it is of three distinct classes: first, the motion which imitates the movement of real objects, such as the turning of the wheels of the motor car and the fluttering of the veil in the breeze; second, the conventionalization of motions of the first class, such as the calisthenics of the Wrigley spearmen; and third, motion which has no meaning, motion for motion's sake, simply because, other things being equal, of two objects, the moving one attracts the eye first.

REAL MOTION REPRODUCED

There are great undeveloped possibilities in each of these classes. In the first, the picturing of real movement, nothing can be better or more natural than the closest possible reproduction of the original motion. This has been done to a remarkable degree in a few very large signs only. Most attempts at this kind of motion, however, have failed; largely because the sign was too small to get all the steps in, or though large enough because too few steps were made. It is hard to conceive of any continuous and smooth motion as defined by three or four stationary pictures. The motion picture expert would tell you that it takes dozens to show very small movements even. Probably if sketches were made giving full value to the correct width of the lines of light for each of the three or four positions which are used in electric sign motions of this sort and if these sketches were photographed on motion picture film and thrown on a screen and shown to the man who pays the bills, most of these real motion portrayal signs would be changed either to the conventional movement class or the motion-for motion's sake class; or else several more steps in the real motion would be put in.

MOTION FOR MOTION'S SAKE

The third class of moving signs has been used to a very much greater extent. There are almost as many flashing or flickering

or running borders and flashing signs as there are still ones. A few more complicated movements have been used also. The sign which flashes two or more messages is very popular; signs which obtain curious effects by flashing different colors are quite common; signs which, like the Mason monogram and the clock and carriage call signs, by a change of control made be made to have any desired reading, have been built; and signs in which the wording drifts by over a bank of lamps are quite effective. Probably as roof sign competition becomes more keen in the future, some of the older ideas which either have never been built or have been built and abandoned because they were expensive, or because of mechanical defects, will be used again. If it pays to put from 100 to 300 kilowatts of electrical energy into a sign which burns steadily with one message, and it has been proved that it does, it would probably pay some competitor to have a sign which is controlled by a huge typewriter-like machine and on which an operator could spell out messages at will; or it might pay to have a bank of closely spaced lamps, like that on which the words drift across, with a control board similar to it in miniature, so connected that a cartoonist could draw cartoons on the control board that would be reproduced in lines of light on the sign. The people in the square below could watch the picture develop. A written message could follow the picture and then a new cycle could start, and there would be never two alike. These and many other complicated and unique moving signs have been tried and will probably be tried again.

DRIFTING LETTER SIGN VARIATION

There is a variation of the drifting letter sign which I believe is new and which might be very effective. If the lamp bank consisted of two sets of lamps, one of small clear glass lamps and the other of larger blue lamps, a purely mechanical design could be drifted across on the lamps of lower intensity, or preferably the same design or different designs could be drifted across in the two opposite directions, so that the motion of the pattern in light would be horizontal and vertical and figures of expanding squares could be followed by contracting circles and all of the infinite varieties of moving patterns possible to such an arrangement could be going on continuously. Then at certain intervals,

this whole moving background pattern could be dimmed and on the brighter lamp bank, a stationary reading message could be brought simultaneously up to full brilliance. I believe the effect would be startling and pleasing and the whole thing with a large number of separate messages could be done automatically. Or better still with an operator the message need never be twice alike.

DIMMING

There are so many variations of conventional motion which could be used in electric sign design that we might talk indefinitely about these alone. But there is one other motion that should be mentioned. The simplest conventional movement used in electrical signs is effected by flashing a sign off and on. It is used very largely where there are two signs facing in opposite directions. The flashing is done from one side to the other. Beside securing motion, half the energy bill is saved and since the total line load is constant except for slight disturbances at the time of flashing, there is no surge on the line as there is likely to be when a very large sign is simply flashed on and off. If instead of flashing the sign abruptly on and off, it is dimmed down to a low intensity and then brought again up to full brightness, slow rhythm of continuous movement will be obtained which is extremely effective. An additional advantage in this form of motion is that as the lamps are dimmed the maximum distance of legibility is increased so that at different points in the cycle such a sign has as great attracting power as is possible from extremely bright lamps and as great legibility distance as any sign of this size can possibly have, and its unusual nature would give it extraordinary selling power.

ENCLOSED LAMP SIGNS

So far we have been dealing entirely with signs of the exposed lamp type. We found that it was impossible to make signs of that type which were to be seen at distances less than about 300 feet and in which the lines of light which made up the strokes of the letters appeared continuous because the lamps for mechanical reasons could not be spaced on centers less than 3 inches. There will always be some advertisers who will prefer the brightness and sparkle and even the spotted effect of signs

with lamps spaced more widely than the recommended spacing of Table III, or of signs with the minimum spacing when seen at distances less than the minimum distances given in that same table. Probably the majority of persons, however, prefer signs seen at these shorter distances whose lines are smooth and clear cut, such as are obtained in translucent letter signs. Objection is sometimes made that such a sign is not as bright as an exposed lamp sign and that for this reason, translucent letter signs will be forced out of the brighter streets. It is ordinarily not practicable nor at all desirable that the luminous parts of a translucent glass sign be as bright as an incandescent filament. Such letters would be entirely illegible and unbearable. It is generally accepted, however, that for all except districts of very high illumination or extra keen competition the smoother, more even and sharper outline of the illuminated translucent letters give them so much advantage over the spotted and irregular but more sparkling appearance of the exposed lamp sign, that the brightness need not be so high to compete successfully.

LAMP SPACING FOR ENCLOSED LAMP SIGNS

For signs of this type, however, a certain minimum average brightness is desirable and especially must the variation in brightness in the different parts of the sign be kept at a minimum. Althrough designers do not all agree, a fairly safe rule for lamp spacing for translucent letter signs is the following.

For enclosed lamp signs using opal glass designs in which the lamps are to be located four to five inches from the illuminated surface, the lamp filament spacing for large patterns should not be greater than six inches in each direction. Where the translucent pattern consists of letters which are six inches or more in height or where there are figures which are repeated so that it is especially essential that each be illuminated alike, it is better to use a uniform number of lamps per letter or figure. The proper number of lamps may be obtained by dividing the number of square inches of letter surface (including the opaque sections between the strokes) by 40 and using the nearest even number to the quotient. This rule of spacing like nearly every general rule, has many exceptions. It should be used as a basis of a careful layout of the sockets rather than as a strict all-inclusive

rule. Where one set of lamps illuminates two sides of a sign, the lamp spacing will have to be a compromise, using however the lamps according to the closer rather than the wider spacing as calculated from the letter dimensions on either side. An extra lamp installed in the sign will cause less loss in smoothness than will a lamp left out. For the lowest street illumination with such a socket spacing, 25-watt lamps may be used. For streets of medium brightness and in this class most of these signs may be considered to be located, 50-watt lamps are satisfactory. For very bright districts, 75-watt lamps should be used. With the opal glass which is used in large quantities for sign letters of this type and with painted or stained glass of about the same density, lamp spacing of this order will produce signs of apparently quite uniform brightness. If the distance from the lamps to the lighted surface is very much greater than six inches, larger lamps spaced more widely may be used to obtain the same surface illumination. A large part of the advantage of a translucent letter sign—its smooth, uniformly illuminated appearance—is lost when the socket spacing is so great that the individual lamps show through.

ENCLOSED LAMP SIGNS PAINTED WHITE INSIDE

A most important requirement in the design of a translucent letter box sign is a good white reflecting paint or enamel finish for the inside of the box. Curiously enough, most enclosed lamp sign manufacturers ignore this very important point and so throw away a very substantial part of the available light.

MAINTENANCE

There is just one other phase of the improvement of signs which I want to mention. This is maintenance. Electric signs are to store fronts what neckties are to men. When they get soiled and neglected and when a lamp or two is missing, the store begins to take on the tramp-like appearance of the man with a frayed and badly tied necktie. In general better advertising value over a period of a year or more will be obtained from a small sign which is washed and cleaned just as often as the show window is washed, and which is painted and has change of lamps say three or four times a year, than will be obtained from a sign

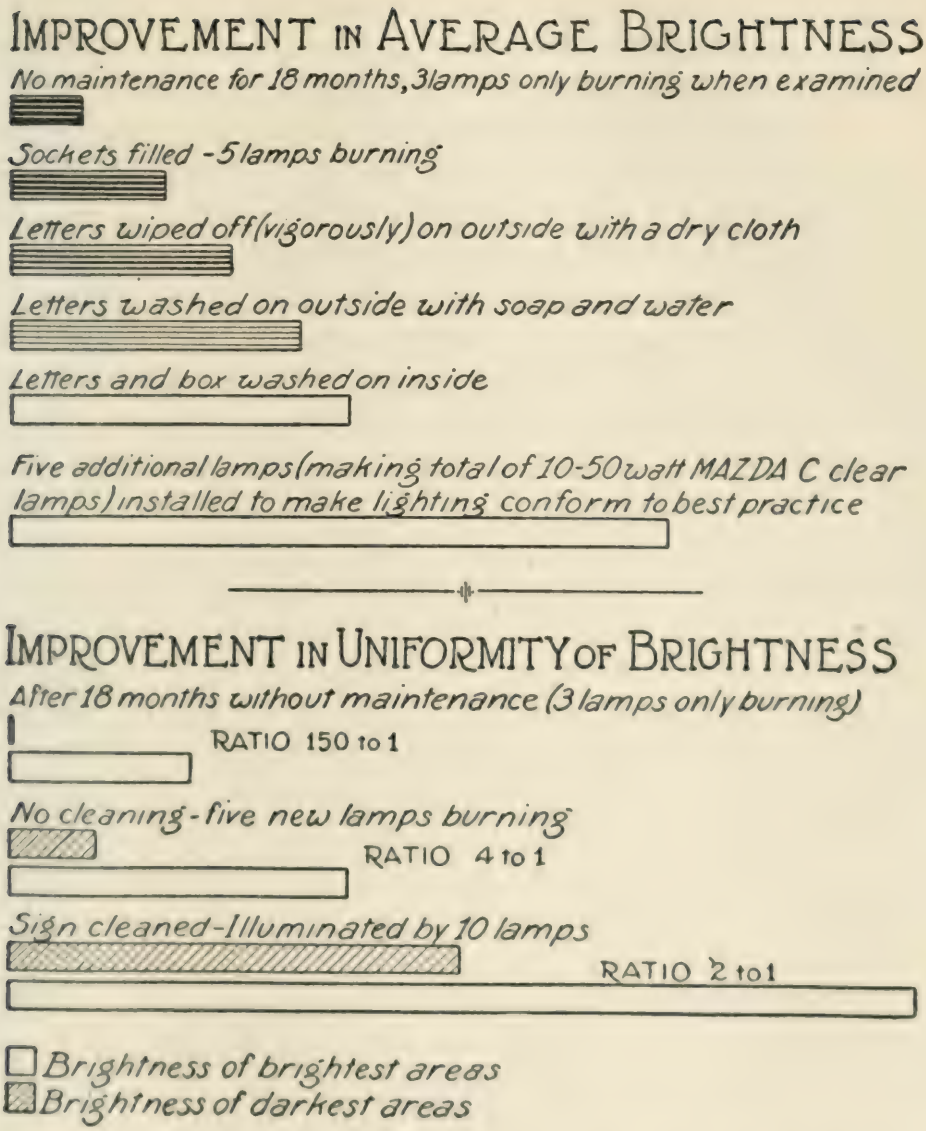

Fig. 17.—An enclosed sign containing ten 6 inch opal glass raised letters, provided with five sockets, three only of which contained 50-watt White MAZDA lamps when examined, had been in operation without maintenance for eighteen months. It was relamped and cleaned with the results shown in this chart.

twice the size which is neglected until it is dirty and five or ten per cent of the lamps are burned out.

While the need for adequate maintenance exists for all signs, it is more important for the small ones than for the large ones, and it is especially needed for translucent letter signs. In such signs there are three surfaces to be kept clean. Only one of these

is exposed to the street dust but although the others are inside and somewhat protected they are never washed by the rain as are the lamps in an exposed lamp sign. Practically all of these signs have a neat and clean appearance when new but show slight deposits of dirt quickly. For this reason box signs should be so constructed that the inside of the letters may be easily reached or, preferably, that the letters may be removed and washed in soap and water, not merely rubbed off, but washed in the water frequently. Making box signs with removable letters similar to theatre feature boards increases their cost only 20 per cent and makes it possible to have a sign which always looks like new.

To evaluate the effect of cleaning a translucent letter sign, such a sign was examined recently. The brightness in five positions was measured both before and after cleaning, and after replacing the lamps with the proper number of new ones of the correct size. The results are best shown in Figure 17. The average brightness of the sign was increased twelve times, the ratio of the brightness of the bright spots to that of the dull spots in the sign was reduced from one hundred and fifty to one to two to one. It is probably true that, in these lower ranges the attracting power of a sign is increased at least in proportion to that of the average brightness and the selling power inversely as the variation in brightness.

There are many ways in which a sign may be systematically maintained. Sometimes the central station sign department undertakes this work. Sign maintenance companies, and some sign companies, are equipped to render this service. Any method is good as long as it is systematic and thorough. The owner himself rarely makes a good maintenance man because he lacks the training and because he can so easily yield to the temptation to "put the work off" from day to day.

DISCUSSION

The paper by Mr. C. A. Atherton was discussed through correspondence.

H. C. YOUNG: It is my impression that Outline Lighting has become practically obsolete in this country, and that it is no longer considered good practice. From my personal observation, there are very few outline installations now being used, even in the

large cities. Will Mr. Atherton tell us whether or not this kind of lighting is now favored by lighting men and by electrical advertising men; also, whether an appreciable number of new installations of this class are being made in this country?

A. H. Taylor: Mr. Atherton's paper is a very valuable contribution to a branch of illuminating engineering which has not received the serious consideration which it deserves. It should prove of immense value to designers of electric signs.

I should like to ask whether the apparent spot size would be the same for clear and diffusing bulb lamps of equal tip candlepower. Also, has any comparison been made of the relative spot sizes as determined by the eye and by the camera?

E. B. Fox: Mr. Atherton has covered the subject in great detail, and his ideas are most constructive. It seems to me that the tendency from now on will be in the direction of new and beautiful color effects rather than in greater brilliancy of the light source.

The best method of procuring these effects will be through the development of color caps of blown glass, rather than the present heavy pressed glass. There are a number of colored glasses which can be used for the work and with thinner caps there will be much less absorption than with the heavy ones, and the signs will appear brighter and more pleasing.

With sets of caps of different colors it will be possible to change the color of the whole sign or parts of it any time that the owner thinks it advisable to get a new effect. We hope that it will be possible to use the same light blue glass for these caps that is now used on sign lamps to give the very white brilliant effect that is so often seen in signs in the larger cities of the country. This glass is also used for gas-filled Daylight lamps.

Where very even lighting of the letter is required the color cap itself could be frosted or a frosted cap could be used without color. Most dipped and sprayed lamps will fade or the color will wash off in the rain. These troubles are overcome by the caps.

Where high wattage gas-filled lamps are used for sign lighting they are burned horizontally and there is a small hot spot just above the filament. If this is struck by cold rain or snow the bulb is apt to crack and the filament burn out. A glass cap properly

designed for these lamps would not get nearly as hot as the bulb and would act as a protection against rain or snow.

From the standpoint of the sign owner the advantages of color caps are obvious. Colored lamps are expensive and not kept in dealers' stock, so that signs will often be very ragged because the owner cannot procure lamps when they are needed. Clear lamps can always be quickly procured and renewal costs are low.

In the case of enclosed signs it would be a much better proposition to have the letters tinted by a sheet of thin colored glass behind them, rather than by the use of colored lamps. If the color is superficial it is apt to come off as the lamps get quite hot in the enclosed box. As stated before lamps made of colored glass are expensive, but in this case I understand that putting the coloring matter in the letter itself is an expensive and not very satisfactory proposition and more variety can be gained through the use of thin glass plates which can be easily changed.

E. A. MILLS: Mr. Atherton's paper entitled "Better Signs" covers the subject so thoroughly that there is very little to add to what he has already said. He has treated the subject under various headings and each of these has been covered very exhaustively. It is quite true that architects are now considering the design of electric signs in connection with their building plans. This applies not only to a sign of proper design and in keeping with the outside appearance of the structure but also applies to the illuminated interior sign of a directional character to work in with the architectural layout of the building as contrasted with the haphazard manner in which these signs have been made up and placed in the past.

While the electric sign is primarily used by night, its daylight appearance should also be considered and I believe this factor is now given more thought by sign manufacturers than at any time in the past.

Mr. Atherton is to be congratulated on evolving the equations which give the proper spacing of lamps. Lamp spacing in the past has been more or less of a hit and miss proposition, there being no set rule for spacing, other, than the individual manufacturer's experience. We are all acquainted with instances where an effort has been made to outline a trademark of rather intri-

cate design with lamps of high candlepower and have noted the very unsatisfactory appearance of such a layout, particularly where the sign is so located that it is viewed as a close up, the effect is anything but good and the glare very objectionable. Repetition of such installations will be avoided by closely following the recommendations made in Mr. Atherton's paper.

The suggestion of using an illuminated border of high candlepower lamps to a sign involving considerable detail and made up of lamps of lower candlepower is I believe a factor that the majority of sign manufacturers have overlooked and this suggestion should help in materially improving the effectiveness of signs of this character.

Mr. Atherton's suggestion of using dimmers in connection with spectacular displays is certainly unique and I feel sure that we shall see signs involving this characteristic in use very soon.

It is indeed surprising to find out that the majority of manufacturers failed to use white paint on the inside of translucent signs as it is apparent to anyone that this will improve the effectiveness of such a sign and I believe that the suggestion will be welcomed by manufacturers of signs of this character.

I cannot lay too much stress upon the subject of maintenance as brought out by Mr. Atherton. Experience in the past shows that while the consumer is willing to pay a considerable sum for an electric sign the question of maintenance is entirely overlooked and nothing creates a worse impression than an electric sign with missing lamps and dull paint. While the central stations in some cities furnish maintenance of a limited nature, in New York City we have found that this work is best taken care of by one who specializes in this work and is equipped with the proper facilities to make repairs to flashers, replace burned out lamps and repaint dull or discolored paint. Located as they are in many instances in inaccessible places requires the services of a specialized class of workmen not generally employed by central stations and the work presents a certain life hazard which the central station does not feel willing to assume.

J. M. Gilchrist: For the designing of large display installations the facts and figures, that Mr. Atherton has presented, should be of great value. I think, however, that their use in con-

nection with the smaller signs which constitute the great majority of the signs purchased will be necessarily rather limited. In his discussion of the interior illuminated sign he has overlooked one feature that should not be neglected, which is that general illumination on the store front and on the sidewalk, which you do not get from the interior illuminated signs, has of itself great advertising and sales value.

Technically, the interior illuminated sign may be the better sign, although I do not personally admit it. There is no question but that on two streets of average illumination, one of which had nothing but interior illuminated signs upon it, and the other one nothing but exterior illuminated signs, that the larger crowd would walk upon the street having the exterior illuminated signs, simply because of the increased brilliancy of illumination upon that street. I think this is the big feature that should be considered as between the exterior illuminated and the interior illuminated sign.

We are making as many interior illuminated signs as exterior illuminated signs, but we are looking forward to seeing the trend back to exterior illuminated signs. We have seen a good many of what you might call freak signs of various kinds come and go while we have been in business, and while we do not call the interior illuminated sign a freak sign; at the same time we feel that it lacks a very important characteristic, which is needful if it is going to continue in its present popularity.

I fully agree with Mr. Atherton's conclusions as to maintenance including the renewal of lamps and the cleaning of signs. There is no question but that the man who does not properly maintain his sign is not getting anywhere near the value which he should get from the money expended, and there is also no question but that the average merchant who attempts to maintain his own sign does not maintain it, he has just failed to spend the additional small amount that is necessary to give his advertising the continuous punch which it should have.

I note Mr. Atherton's comments on the failure of manufacturers to paint the insides of interior illuminated signs white. It is our experience that so great a proportion of the inside surface of a sign is white glass, which has very good reflecting qualities,

that, except in single face signs the painting of the balance of the interior white has very little effect.

Referring to Mr. Atherton's suggestions on the changing of the reading and the design on display signs, I agree with him fully that this should be done as often as possible. It may not be feasible to change it every week or every month, but the cost of changing it every year is not prohibitive as compared to the total cost of sign, and the average display sign advertiser who also uses newspaper and magazine space, would not think for a minute of running the same copy year after year in his newspaper and magazine publicity, and he should not think of running the same electric sign more than a year, and if possible it ought to be changed during the year.

L. F. R. Bellows: In general I can agree with Mr. Atherton that there is a great future for the electric sign as an advertising medium. There can be no doubt of its advertising value and its adaptability to either the large spectacular display for general publicity or the smaller form which is erected over the merchant's door for the purpose of fixing his location and his line in the minds of the public and localizing the value of all other advertising which he may do.

Electric sign advertising in one form or another will undoubtedly be used for many years to come but whether it reaches its maximum efficiency will, in the writer's opinion, depend very largely on the attitude taken during the next comparatively few years by men who are engaged in the manufacture and distribution of electric signs.

From a technical standpoint Mr. Atherton's paper is fine and I am certain that the data which he has presented will be very eagerly studied by a large number of responsible manufacturers who are far sighted enough to realize the necessity of continually improving their product if it is to survive. It is hoped that this will be the first of a great many similar articles which if properly distributed will eventually help the electric sign advertising business to a higher plane of efficiency. I was intensely interested in the first part of Mr. Atherton's paper but after reading the last page and reviewing the paper as a whole I was more strongly impressed with the last few pages than any other part.

The design and construction of large spectacular displays is very largely in the hands of responsible manufacturers and such displays in most cases are maintained and operated by the manufacturer and a continuation of his contract as well as the securing of other contracts is largely dependant on the result achieved by his work. These manufacturers will not fail to profit by such papers as Mr. Atherton has written and I see no reason why this form of electric sign advertising should not increase in use very rapidly.

The matter of the smaller electric signs which are more generally used for localized advertising and in the majority of cases are suspended over the public highways is one which requires a great deal of attention in the immediate future if it is to prosper. The last few pages of Mr. Atherton's paper dealing with the maintenance of electric signs applies almost exclusively to this form of electric signs. The subject of maintenance is the most vital matter confronting the manufacture of this type of sign at this time. There are few cities in this country in which the number of signs of this type which are detrimental to the trade do not predominate.

It seems ridiculous that the average American business man will spend good money for this form of advertising and then fail to insist on its being kept up to its full working efficiency. Although ridiculous this is the actual condition and the manufacturer of signs of this type must wake up to the need of selling maintenance if their business is to prosper. The paper under discussion points the way to selling sign advertising instead of merely selling a sign and unless more attention is paid to the proper maintaining of our projecting signs it is not unreasonable to expect that eventually a wave of public opinion against the cluttering of our streets by these structures which are allowed to get in unsightly condition will force a serious curtailment on this form of sign advertising. The situation of these manufacturers to-day is very similar to that which confronted the bulletin and poster advertising men a number of years ago and forced them to the front rank in the advertising field by making them clean up their displays or be legislated out of business.

The fact that the far sighted manufacturers of electric signs are waking up to the seriousness of the maintenance situation is

well illustrated by the fact that the largest concern in the interior illuminating sign field, doing not only a national but an international business has had a force in the field for some time organizing a national maintenance system for their product.

Mr. Atherton's paper is very timely and it is sincerely hoped that more work will be done along this same line to the end that electric sign advertising may be placed on a more secure basis as it is only by improving the product and then seeing that it is kept up to maximum efficiency that we may hope to reach the ultimate developments in this form of advertising.

S. G. Hibben: In this discussion of the engineering factors of sign design and use, the author has admirably given the results of a great deal of careful work. The purely scientific study has evolved some tables and equations that show the way toward much-needed improvement in sign construction; now comes the problem of translating these data into simplified and easily workable material, and of convincing the sign builder and owner that in this field, as in other branches of illumination, there is much definite knowledge and many a guiding law; that sign engineering should not be considered guess work.

We may have wondered why electric signs have not been more extensively used. I believe the closest answer is that they have not been artistically and architecturally fitting. They have been almost ugly; too frequently they offend the eye, particularly in the daytime, and when we see signs that dress up a building about like a bill placard dresses up a sandwich-man, we need not wonder that an organization like the Merchant's Association of New York have refused to permit all signs being used on some prominent metropolitan street of higher class. Here is food for thought. For the preservation of the electric sign, artistry is needed fully as much as cold-blooded engineering.

When speaking of color in sign lighting, it is interesting to consider the field of both colored lamps, and colorhoods or caps. There are cases, as on elevated signs above traffic, where a glass color-cap is a distinct menace. Up to this time the superficially colored lamp is the only answer to that problem, and much is yet to be done in perfecting applied color, that will not fade or chip off, for exposed lamps in channel or flat-faced letters. It

is gratifying to note that during the recent months the art of coloring Mazda lamps has greatly improved. Nevertheless the good engineer will see here a field for a light-weight color-hood or cap of fire-proof fabric, pyralin or cellulose acetate that would slip over the end of the lamp bulb.

Some of the signs using the blue glass lamps have been noticed to gradually become spotted. The first idea would be that these lamps fade out, and grow less blue-white, but upon investigation it appears that a deposited film of greasy dust will cause an apparent fading. The cure is simple, merely a cleaning of the bulb.

Drifting letter or talking signs are appearing in places of dense traffic. They introduce special lamp problems, as for example the rapidity of heating and cooling of filaments. In Chicago, New York, and a few other cities we see such signs, of about one hundred feet in length, that consist of a solid bank of perhaps four thousand lamps. Groups of four lamps each are connected on a circuit, and contactor fingers are arranged for each of these groups. A moving sheet of paper is passed under these contacts, and where holes are perforated in the paper, the fingers drop through to make contact. The fastest speed possible is sought, to utilize the sign to the utmost. At about twenty feet per second the lamps get only an instantaneous flash, and the cooling of filaments limits the speed, because when lamps remain glowing there is a blurring of letters or a comet's tail effect on the following edges of the letter strokes. So far the best success has resulted from the 10- or 15-watt straight filament lamps.

Signs of cut-out letters backed by diffusing glass, or painted transparencies, depend as much on the quality of the glass as upon the placement of lamps behind the glass or sign face. It is common knowledge that higher transmission of light is secured when all roughed glass surfaces are placed on the inside, facing towards the lamps. It is not so commonly known that transmissions are higher if the lamps are not too close to the glass, so that the incident light does not strike at grazing or oblique angles and hence be reflected back in. Tests show that if the brightness of the brightest spot on a diffusing glass is approximately four times the brightness of the darkest part on the glass, the illumina-

tion appears uniform. Greater differences of brightness cause spotted effects.

J. M. SHUTE: The rapid growth of the demand for electrically lighted signs has opened a wide field to the illuminating engineer. There can be no doubt in the mind of anyone connected with the electric sign industry of the value of the facts brought out in Mr. Atherton's paper, as a result of his tests.

In the past the tendency has been, as in the case of so many other articles for which there has been a sudden demand, to follow the path of least resistance and utilize things which had been used elsewhere or perhaps were most particularly suited to some other purposes. No doubt this tendency in a great part was due to lack of knowledge of fundamental principles governing the use of such signs.

The attitude of the majority of architects toward this form of advertising greatly narrowed the latitude of design in the past, but, with the present knowledge of the governing factors and the realization of the value of artistic signs, we should in the near future see far more elaborate displays than ever dreamed of previously.

Too much stress cannot be laid on the value of color and motion in future electric sign displays. The ever increasing number of "daylight" signs using the blue bulb lamps will soon make the sign lighted by clear glass lamps the outstanding one. The beautiful and attention-compelling signs made up of ingenious combinations of the various colors at our command will probably in the future play much more important parts in large display signs. It seems as if the economic and mechanically safe limits in the matter of intensity have been almost reached with the present lamp equipment, so if the electric advertising competition is to go on at its present rate these other factors must be given proper attention to aid the factor of light intensity.

The flasher, to cause rapid changes in the messages or picture, has been used successfully for a number of years. Both the increased advertising value and decreased current consumption have lead to the wide use of such devices. The use of dimming devices, by means of which gradual changes in the intensity of the message sent out can be obtained, has been greatly neglected.

Such devices while not causing the quick attention-compelling change of the flasher can bring out words or pictures in such forms as to be visible and readable to spectators at varying distances from the sign itself. A sign controlled by such a device could at one moment be the most brilliant display in the locality while at the next would be readable at a much greater distance due to the less intense light given off. Such a sign would have not only all the advantages of the present sign with motional effects but also the added attraction caused by the novelty of such a display. Future signs may be equipped with such novel devices thus greatly adding to the many diversifications available for the use of the electric advertiser.

F. C. REILLY: Mr. Atherton's paper is evidence of an extremely careful, and allsided study of the design and construction of electric signs; the influences and restrictions effecting their installation, and the necessity for devoting more real thought to the planning of electric signs than has been the custom, generally speaking, in the past.

The productions of a relatively small number of sign manufacturers have evidenced the serious thought that they have given to the design, lamp spacing, size of lamps and mechanical construction but such critisism as has been made of the electric sign, as an institution, has been largely because of the installations which had little or no thought given to their design, construction and erection.

As our business is principally with national advertisers, the larger local advertisers and motion picture theatres, outdoor advertising companies and central stations, I do not encounter the same situations as are met by the commercial sign manufacturers.

We are selling "Electrical Advertising" and for a number of years past there has been a continued, and very marked, inclination, among the country's prominent advertisers, to regard electricity as a medium having just as definite a purpose, and value, as magazine and newspaper space, billposting or street car advertising.

Several years ago we realized that the spectacular electric sign, representing a very considerable construction expense, occupying

a high-priced location and having a high operating cost, could not be successfully merchandised, in good times and bad, unless the advertiser, who ultimately foots the bills, was provided with a means of effecting a complete change of copy at frequent intervals, without excessive cost. My experience in connection with the design and operation of certain of the best-remembered spectacular electric signs, demonstrated that a display in which the spectacular effect overshadowed the advertising was due to be short-lived. We set about the development of a display in which the spectacular effect would be the advertising itself; an achievement represented to-day by the sign with the moving letters.

We have found that the national advertiser has always felt that the spectacular electric sign that displayed only a name and a trademark, or slogan, was an excellent thing when new but that it quickly became a land-mark, wherever located, and that it lacked the versatility of the other advertising mediums with which it was forced to compete.

The big advertisers have always conceded electric advertising to be attractive, possessed of a "punch" equalled by no other medium, distinctive and only lacking in that freedom of copy-change possessed by the magazine and newspaper. We have provided the advertiser with a spectacular feature that dominates any type of border or design with which it may be surrounded, and which, by simply changing the perforated roll that operates the display, affords the advertiser to effect a complete change of copy weekly, or as often as desired.

The electric sign is due for an enormously increased use, not so much in Times Square for there is now hardly a square foot of vacant roof space available, throughout the United States and there is an inestimable amount of money to be saved, and better results to be obtained, by a careful analysis of Mr. Atherton's paper and putting into practice the principles to which our attention has been directed.

In line with the thought expressed by Mr. Atherton concerning the possible development of an electrical display, operated by an attendant, arranged to provide continual changes of announcements and advertisements; we perfected a sign of this type several years ago, which we have not attempted to place

on the market for the reason that the field for which this is best suited, as a bulletin for the metropolitan newspapers, is not a profitable one.

HAROLD CUSACK: The concensus of opinion is that Mr. Atherton has made a distinct and extremely valuable contribution to the science of sign building. In a most effective manner, he has handled the subject so as to inspire the trade and at the same time enlighten the lay-public.

The article is so full of splendid "meaty" information that it is hard to pick out particular "high-spots." We are, however, especially interested in his treatment of the part architects are coming to play in the designing of signs and in his emphasis of the value of dependable maintenance. Our experience confirms Mr. Atherton's statement that there has been a marked increase in the recognition, by architects, of the desirability of incorporating the design for a sign in with the design for the building. We have found this especially true in the designing of theatres.

In that portion of the paper relating to maintenance, there are two especially constructive thoughts. One is the evaluation of the effect of cleaning a translucent letter sign and the other is the tendency on the part of the sign-owner to procrastinate if he undertakes his own maintenance work.

A. H. FORD: It is to be hoped that the publication of such simple rules for the determination of the legibility of electric signs under various conditions will prevent the prevalent waste of money on illegible signs.

A skeleton sign is visible against the sky in the daytime because its brightness is less than that of the sky. Ignorance of this fact often leads to the painting of such a sign a light color, which renders it less visible in the daytime. The letters should always be painted dark and the framework light. One of the best reflectors is that obtained by the use of aluminum paint. Covering the framework with this kind of paint should render it less visible in the daytime. The framework is usually very feebly illuminated at night so painting it this color should not make it unduly conspicuous. Where the background is a building the framework should be painted to match this, with the letters a contrasting color.

SIGNAL CONTROL OF TRAFFIC*

BY DR. JOHN A. HARRISS**

The results obtained through the installation of a unified system of signal control in the regulation of traffic in the City of New York have established the practicability of such a method beyond the shadow of a doubt. It is a decided step forward in the way of relieving congestion and expediting the movement of vehicular traffic in the busier centres, and contributes in no small measure towards the safety of pedestrians while crossing our thoroughfares where the heaviest volume of vehicular traffic is to be found. Put into effect in what is conceded to be the most congested traffic thoroughfare in any of the larger cities of the world, that is, Fifth Avenue, between 30th and 60th Streets, New York City, it at once demonstrated its efficiency in a manner to confound even the most skeptic, who viewed the situation as impossible of solution.

For several years prior to the installation of the flashlight system on Fifth Avenue, congested traffic conditions on that thoroughfare had become so intense as to make anything like a fluent and expeditious movement of traffic quite impossible, and something very radical had to be done to cope with this situation. While the assignment of traffic patrolmen to the various street intersections and the use of the "Stop" and "Go" semaphores were rendering a service as efficient as could be expected, they were entirely inadequate for the proper handling of the abnormal volume of vehicular traffic traversing Fifth Avenue daily, in recent years. It was plainly apparent that an innovation in the methods of traffic regulation must be instituted without delay before things would arrive at such a stage as to get beyond control. By actual test it was found to have taken as long as forty minutes for a vehicle to proceed on Fifth Avenue, from 57th to 34th Streets, or in the reverse direction at certain times of the day, and at some specific points the traffic congestion had become so intense as to practically render them impassable.

* A paper read by Inspector John O'Brien, Police Dept., City of New York, before the New York Section of the Illuminating Engineering Society, December [illegible]

** Special Deputy Police Commissioner, City of New York.

After prolonged and deep study and consideration of various measures of relief, including a possible one way regulation at certain periods of the day; it was felt that the solution was to be found in a method of signalling that would clearly indicate and control the movement of traffic over a reasonable distance, and the adoption of a flashlight system, using different colored lights as a medium of direction to proceed, stop, and change in direction was then decided upon as the most effective of the contemplated plans to improve conditions.

Accordingly signal towers were erected on Fifth Avenue at 57th, 50th, 42nd, 38th and 34th Streets, modeled somewhat similar to signal towers on railroads, for the control of the movement of traffic on Fifth Avenue and cross streets by flashlights, telephone and push button signals operating between the towers and to be observed by the traffic officers assigned to duty at street intersections. The floors of the towers are twelve feet above the roadway so as to afford a clear view for their occupants, and the towers are so provided at the base as to sheer off passing vehicles, thus becoming, in addition to their specific purpose, "Isles of Safety" for pedestrians crossing the avenue at those points.

The master tower, controlling the operation of the remaining towers, is located at 42d Street, and the movement of traffic averages about one and a half minutes for that on the avenue, as against one minute for the traffic from cross streets. Prior to the change of signals a bell is rung to attract the attention of the policeman assigned to crossings that a change in the direction of traffic is about to take place. The telephones are used for the purpose of transmitting necessary police information between the towers, or in case of any disorder to transmit the signals, in lieu of the flashlights becoming disarranged.

The signals flashed from the towers indicate the following: *Yellow*; Traffic moves on Fifth Avenue and all cross traffic from side streets stops behind the building lines, or white limit lines when marked on the roadway. *Red*; All traffic on Fifth Avenue as well as side streets stops behind the building lines, or white limit lines when marked on the roadway. *Green*; Traffic from

side streets proceeds. The signals are in operation from 8 A. M. until 12 P. M. and regulate the movement not only of vehicular traffic, but also apply to pedestrians in crossing the roadways, which they must do at the regularly designated crossings.

Under the new regulation congestion has been eliminated, and the annoying and costly delay experienced prior to its inception has been reduced by more than 60 per cent. It has also resulted in a saving of wear and tear upon vehicles and the elimination of much inconvenience to individuals. Such excellent results have been obtained from the system that we are endeavoring to obtain sufficient funds to extend it to the busier sections of other thoroughfares throughout the city not only in the Borough of Manhattan but in the Borough of Brooklyn as well.

DISCUSSION

The papers by Messrs. Harriss, O'Brien, Taylor and Warner were discussed together. See page 260.

FLASHLIGHT SIGNAL CONTROL OF TRAFFIC*

BY JOHN O'BRIEN**

The nearest thing to the human hand for signaling is the flashlight. There is more life in a flashlight than there is in anything else except the human hand. The success of the flashlight signaling system in operation on Fifth Avenue, Manhattan, is so apparent that I have strongly advocated the extension of these lights to many other important thoroughfares throughout the city, and if we can only prevail upon the officials who have the power to appropriate the money necessary for this purpose, the traffic on many more thoroughfares in this city will be regulated in like manner.

As you know it requires a great deal of money to extend the flashlight system, similar to the one now on or proposed for Fifth Avenue. Fifth Avenue towers as they now appear are only temporary affairs, which were placed there at the expense of Dr. John A. Harriss, Deputy Commissioner in charge of traffic, for the sole purpose of demonstrating whether or not they were a practical means of controlling traffic. They have so clearly shown their practicability and worth that they are no longer in the experimental stage, and for that reason the Fifth Avenue Association have or are now considering the advisability of erecting towers at their own expense in keeping with the dignity of Fifth Avenue. It is proposed to replace these temporary towers by more artistic ones, which will add to the beauty of the avenue.

While these towers are of great value in the control of traffic insofar as they apply to Fifth Avenue, they cannot be used to the same advantage in all parts of the city where we have traffic control by lights in mind. For instance, the roadways of Broadway, Sixth, Seventh and Eighth Avenues in Manhattan and Bedford Avenue in Brooklyn are not of sufficient width, especially where there are street car lines, to permit the erection of a tower in the centre of the street, and consequently on these and

* A paper presented before the New York Section of the Illuminating Engineering Society, December 15, 1921.

** Inspector in charge of traffic, Police Department, New York City.

similar thoroughfares the lights would have to be placed on poles somewhat like those now used for electric street lamps, and carried over the roadway on an arm, or, if necessary, could be extended all the way across the street, cantilever style, and the lights suspended over the center of the roadway so as to be just as plainly seen by the drivers of vehicles as those now in operation on Fifth Avenue.

Many things can be accomplished by the use of lights. Aside from traffic control, I believe they will be a material aid in reducing the number of street accidents. Many thousands of accidents occur during the course of a year in New York and other cities throughout the country; many fatal, others serious. While it is true that the City of New York has the largest population of any city in the world, with the possible exception of London, the number of accidents in New York City is not anywhere near what it is in other cities throughout the country in comparison with the population of these cities.

Statistics from Washington, D. C., show that in the number of accidents, based on population, New York is thirty-fifth on the list. While this is something to be grateful for, still we have too many accidents, and instead of being thirty-fifth on the list, I believe that by the extension of our proposed lighting system, we can go to the foot of the list.

When we were coming across Fifth Avenue a few moments ago, myself and a few other gentlemen now here, there was no policeman at the corner of 39th Street and 5th Avenue—the lights changed from yellow to red and from red to green—that meant, North and South traffic stop. Now the traffic did stop and yet there was no policeman there to compel obedience to the light; the drivers of those cars stopped of their own accord. It is plainly evident that the drivers obey those lights, therefore we have no trouble at all in that respect—but not so with the pedestrian, he has a total disregard for these signals and we experience considerable trouble in getting him to obey in the same manner.

Some people often ask why we have so many policemen at the corners of 34th and 42nd Streets on Fifth Avenue. The answer is this: When the present flashlight system was first put in

operation, the policemen were placed there to educate the pedestrians. We called these two points our educational centers, we reasoned that if we could get the many thousands of pedestrians who daily cross the street at these particularly congested traffic points to obey the lights, they would invariably do so when they crossed the avenues at other points where lights might be installed. They would at least say to themselves, "If I were at 34th or 42nd Street I would have to wait for the lights to change, now, I will be honest with myself and do the same thing here." At first results were disappointing, but we now find that people are coming more and more to obey the lights, however, it is a tedious job and will require considerably more education along these lines, so you see, lights and education go together.

We have about 30,000 intersecting cross streets in this city and it is an utter impossibility for the City of New York to place a policeman at every one of these crossings. Something has to be done, however, and I am firmly convinced that the only solution is to extend the light system to all of our main thoroughfares. If this were done, we would without doubt be able to show a decided improvement, not only in the efficient handling of traffic, but a more positive and absolute control of it, with a resultant decrease in street accidents, which, after all, is the principal object of police administration.

A considerable number of summonses are issued each year for traffic violations, but the Police Department doesn't glory in that fact. It is their plain duty and an absolute necessity because of the great number of people using our city streets and the many drivers who show a total disregard for their safety. The pedestrian has a right to cross the street. He has what might be termed a priority right over the automobile, and the summons is the principal means of impressing that fact upon reckless drivers and that they must respect the rights of pedestrians and exercise the utmost care in the handling of their cars. During the year 1920 about 61,000 summonses were served by motorcycle policemen alone for speeding and other violations of the traffic regulations and fines aggregating about $750,000 or three quarters of a million dollars collected. The Police Department didn't get any of that $750,000 and so you can readily see there is no glory nor

gain in it for the police—it is their plain sworn duty. When you find people protesting against the number of persons in the Traffic Courts from day to day and saying "What's the use of taking so many people there?" "What are you accomplishing by it?" Just remember what I have previously stated, "insofar as accidents are concerned, New York City stands 35 on the list."

In addition to having the greatest population of any city in the country, we have also the largest floating population. Hundreds of thousands of people daily come into this city from surrounding territory, some as visitors, some on business, some as sightseers and others on pleasure in the evening. If we were credited in the Washington statistics with this additional population, we undoubtedly would be at the foot or near the foot of the list insofar as accidents are concerned.

DISCUSSION

The papers by Messrs. Harriss, O'Brien, Taylor and Warner were discussed together. See page 260.

TRAFFIC REGULATION ON FIFTH AVENUE*

BY SAMUEL W. TAYLOR**

The introduction of light signals on Fifth Avenue has undoubtedly marked an epoch in traffic regulation; it has been revolutionary. Prior to the erection of these towers and the installation of light signals, traffic on Fifth Avenue had become so congested as to be really appalling to those who charged with the safety of the lives of citizens of New York, both in vehicles and on foot. They were a most happy solution of a very difficult problem and Dr. Harriss, the Special Deputy Police Commissioner, evolved this system and put it into operation on the Avenue at his own volition and expense.

It was found that traffic, prior to the introduction of these illuminated signals, was constantly held up owing to the individual control at intersections of the Avenue with the cross streets, by each individual policeman stationed at those intersections. Naturally the human element entered very strongly into that control. The policeman had a very short vision, he could not see beyond a block in either direction, and he was actuated entirely by what we might call "local conditions." The result was that he was holding up traffic or moving it, regardless of what might be going on at the next corner, above or below. Sometimes while he was holding it up, there would be two or three blocks absolutely vacant and if he could have controlled that situation by some synchronized method, such as is now in force, those entire blocks could have been utilized by traffic that was congested at this point.

One of the greatest problems of traffic regulation has been to utilize to the fullest extent the surface of the street, absolutely from curb to curb. In the old days, as you may recall, before this system was put into operation, if traffic was held up at 42nd Street, there would be only one half of the street, that is, one half of the longitudinal side of the street, occupied and the other half would be empty. That space was entirely wasted.

* A paper presented before the New York Section of the Illuminating Engineering Society, December 15, 1921.

** Secretary, Traffic Towers Committee, Fifth Avenue Association, New York City.

In consequence of this, I have always felt, and so have a great many other men who have studied this subject of traffic, that rather than introduce underground or overhead methods of transportation facilities; some means should be found to utilize that space so that the whole surface of the street would be constantly in use to the fullest extent of its area from curb to curb.

These signals, as you have perhaps learned from the paper by Dr. Harriss which was submitted to you a few moments ago, indicate how traffic is controlled from a central point, 42nd Street, and it is constant and fluid, almost liquid traffic now from 42nd to 57th Street. Whereas, it formerly would take forty minutes to go from 59th Street to 34th Street, you can now do it in ten or fifteen, which is a most extraordinary saving.

You gentlemen, as engineers, know that the greatest of all traffic is fluid traffic, the traffic of a river, and that it absolutely possesses every inch of space that the liquid flows over. If we can reach some conditions in our traffic regulations approaching that liquid traffic, I feel that we will have attained the acme, so to speak, of street traffic regulations.

You are doubtless familiar with the fact that the Fifth Avenue Association some time ago offered prizes for the best design of a permanent traffic tower, to take the place of these temporary towers now standing as sentinels on Fifth Avenue. A very beautiful design by Mr. Joseph H. Friedlander has been chosen, out of 130 designs submitted by architects and artists.

The Fifth Avenue Association intends to raise a large sum of money, between $60,000 and perhaps $100,000, to erect these permanent towers in place of the temporary ones; and which will not only be useful in the regulation of traffic, but will be beautiful as adornment to the street and make it an object of interest to people visiting the city from all parts of the country, in fact all parts of the world. It will be one of the most unique thoroughfares that ever existed.

These towers are to be of bronze, very beautifully designed somewhat after the tripod character of the ancient Egyptians; and the tower itself, that is to say, the booth will be occupied by a policeman, as it is to-day. The lights will be the same for

signal purposes, but I think an opportunity is there for the illuminating engineers to suggest something that would add very materially to the artistic side of these towers.

At a recent meeting of the Towers Committee, of which I have the honor to be Secretary, the question of illuminating these towers, in addition to having the signal lights shine forth, was broached. It was suggested that it might be a very beautiful addition to those towers if we had some means of indirectly illuminating the whole tower, making a pile—not a flame—of iridescent light, so that it would be an object of admiration as well as useful in controlling traffic. It was suggested that we might have these lights underneath the floor of the little room in which the policeman stands, to shine below, and someone else recommended that we might have them below so they would shine upward.

Dr. Harriss has recommended, or has in mind, I believe, the placing of a light on the Water Tower below the Washington Arch, which will be visible up Fifth Avenue and control traffic between Washington Square and Madison Square. The illumination of the Washington Arch occurred to me as a possibility. This could not be done of course, during the daytime, but at night, it seems to me we might concentrate spot lights from different directions on the arch, so that when the red signal shines forth, the whole tower will be a beautiful structure in red and alternately, orange and green. That would make the tower a beautiful edifice at night, as well as serving, in addition to the light signals on the top of this tank, a means of controlling traffic.

At the City Hall on last Tuesday I had the pleasure of an interview with Mayor Hylan and this morning he informed me there would be a meeting of the Board of Estimate for the purpose of appropriating a sum of money, I believe something like $250,000, for the purpose of extending these electric signals for the control of traffic throughout different parts of the city.

I believe that is the purpose of the Traffic Bureau, of which we have one of the best traffic men in the world in charge and whom you have heard here tonight, Inspector O'Brien, and I believe it intends to have this traffic movement controlled in a large area of the city from central zones, with lights on the

elevated structures on the East Side, Third Avenue, and on the West Side, Sixth Avenue, and I believe as far as Eighth Avenue, so that when the signal flashes forth for north and south bound traffic to move, it will move simultaneously on Fifth Avenue, Sixth Avenue, Broadway, Seventh and Eighth Avenues and Madison and Park; also alternately on cross streets. You can readily see how such a concerted movement, with the adoption of one-way streets which has been put in force, will facilitate the movement of traffic so there will be no cross-currents and no interruptions.

Of course, that is the ultimate of good traffic regulation; to enable one to get from the starting point to a destination as quickly as possible without danger to vehicle or himself.

I heard Inspector O'Brien say that the pedestrian is the primal factor in street traffic. It is a fact. The human being, of course, whether on foot or in a conveyance, is entitled to be regarded above property. The pedestrian, of course, predominates in number over the vehicles, but he also gets the worst of it when it comes to the force of a collision, as you may readily understand, and therefore must be protected. At the same time, the pedestrian should regard the rights of the drivers of the vehicle. There has been altogether too much defiance on the part of the pedestrian; there has been a latent feeling, we have all felt it, even we who drive cars, when we are on foot, that we have the primordial right of possession of the street and that it is the duty of the man driving the vehicle to look out for us. That is rather a defiant spirit; it is a reckless spirit and is not a co-operative spirit. Unfortunately it is a prevalent one but it is a spirit that should be overcome.

The pedestrian should try his utmost to facilitate the city and traffic departments in trying to solve this terrific problem of moving such a vast number of vehicles so necessary in this complex civilization in which we to-day live.

DISCUSSION

The papers by Messrs. Harriss, O'Brien, Taylor and Warner were discussed together. See page 260.

HIGHWAY TRAFFIC SIGNALING WITH COLORED LIGHTS*

BY EDWARD A. WARNER, JR.**

The control of traffic by semaphore or light indication was first utilized by the railroads. In the beginning this control was effected entirely by the position of a semaphore arm by day and colored lights by night, thus requiring two different kinds of indications for conveying to the engineer the same instructions. Although to-day semaphore signaling is still used to control the major portion of the railroad traffic in this country, there is a growing movement in favor of light signals. The chief arguments in favor of light signals for railway traffic are:

(1) That with light signals, only one indication is used by day and night, whereas with semaphore signals two kinds of indications (day and night) have to be used.

(2) Where the railway is electrified and trolleys used, it is very hard to see a semaphore arm as it may be obscured by catenary supports in front; or if all the supports are in back of the semaphore, it is difficult to discern on account of the background presenting very little contrast. The best indication of a semaphore signal is always obtained with a sky background.

Prominent among the larger railroads adopting light signals are the Chic. Mil. & St. Paul R. R. and the Penn. R. R. In their electrified zones, the former employs long range color light signals and the latter position light signals. It may be of interest to you to know that the D. L. & W. R. R. is at present installing long range color light signals between Newark and Hoboken. I think that a visit to this installation, on its completion, would be of great interest to you.

Color light signals are also used to a great extent by the railroads for highway crossing protection. These signals are of many forms, chiefly among them are:

* A paper presented before the New York Section of the Illuminating Engineering Society, December 15, 1921.

** Union Switch and Signal Company, New York City.

Red lights illumined on the approach of a train and burning steadily.

A single red light flashing on the approach of a train.

A row of red lights which flash in rotation on the approach of a train.

A single red light on a banner arm which is illumined and waves back and forth on the approach of a train.

In practically every case of visual annunciation, a red light is used in connection with highway crossing protection, for it is the most distinctive "Stop" indication with which the public traveling on highways is familiar.

With the increase in highway traffic in large cities it has become necessary to adopt means for controlling it:

(1) With view to expediting traffic movements.

(2) In an endeavor to increase the safety of traffic operation.

Traffic policemen were at first used for the control of highway traffic. By the position or motion of their arms they would indicate "Stop" or "Proceed." As the traffic densities increased, however, it was found necessary to utilize a control indication that was visible to a greater distance and, since it was impossible to find taller policemen, semaphore and lamp stands were adopted. These consist of semaphore arms of various kinds mounted about 8 feet above the street. A traffic policeman at base of the stand would operate by means of a lever the semaphore to different positions, indicating "Stop" or "Proceed." At night a lamp with colored lenses would be used on top of the stand for the same purpose. This semaphore arrangement has practically the same disadvantages as does the semaphore signal on electrified railroads, except that instead of catenary trolley supports to render it indistinguishable, it has in large cities high buildings as a background, but the result is much the same.

The problem of highway traffic control has become such a complex one as to engage the attention of the foremost city officials. The latest development in this problem is that of traffic control by color light signals. Among the foremost advocates of this scheme is Dr. John A. Harriss, the father of Fifth Avenue

signaling. In the selection of a color light signal for highway traffic control there are a number of points to be considered, namely: Efficiency, Range, Location and Method of Control.

The color light signal for highway traffic control should have a high efficiency, that is, for the electric current expended, the light beam should be of very high intensity. Furthermore, in order to reach a high efficiency the light should not be diffused, but should be delivered in a horizontal beam of long range. To attain these results we use in all our color light signals a doublet lens combination consisting of circular Fresnel lenses of high transmission glass, the outer lens being a clear stepped plano-convex lens and the inner a colored convexo-concave lens with steps on the outside. It is also necessary, in the interest of efficiency, that the lamp bulbs be so located as to have their filaments coincide as nearly as possible with the focal point of the lens combination.

With our style "N" color light signal we are able to secure a range of 2,000 to 2,500 feet under the most adverse sunlight conditions. In this style of signal we use one 36-watt, 30-volt, double filament semi-concentrated gas-filled bulb per light unit. The double filament is desirable, for if but one filament were used and this burned out, the unit would be entirely dark and traffic might be tied up. This bulb has a rated life of 2,000 hours and though many bulbs last for a longer period it should nevertheless be replaced at the expiration of this time.

For the high speed main line railroads, where a longer range is desired, we advocate our style "L" signal, which has a range of 4,000 feet under the most adverse sunlight conditions. This type of signal is more easily adjusted than is the style "N" signal. It is equipped with two bulbs per light unit, the front bulb being a 29-watt, 6-volt, concentrated filament vacuum bulb with bayonet base, similar to automobile bulbs. The filament of this bulb is accurately located at the focal point of the lens combination and the base is then cemented in place so that all renewal bulbs will be accurately located. The rear or pilot bulb is of the 25-watt, 55-volt, semi-concentrated type and is used solely to prevent the unit being darkened by burning out of a filament. Both of these bulbs have a rated life of 2,000 hours. To attain a high efficiency

and long range it is necessary to apply the proper voltage to the bulb and for this purpose we used in our style "L" signal a lighting transformer for each light unit. Each light unit of this signal is equipped with an adjustable reflector. In both style "N" and style "L" signals each light unit is equipped with an 8-inch hood to prevent the sun from shining into the front lens and by reflection giving a false indication.

Unlike the semaphore signal, the sky is a very poor background for color light signals for the reason that it provides little contrast. If, therefore, color light signals were mounted on top of a control tower with sky in back they should be provided with a dark background and the same would hold true if there were buildings or signs in back of the signal which were illumined at night. If, however, the color light signals were mounted on the sides of control tower, the background would not then be necessary.

In the present Fifth Avenue signaling, three color indications are displayed up and down the Avenue, *yellow* for "Proceed" north and south, *red* for "Stop" and *green* for "Proceed" east and west. Another method for controlling traffic would be to use only two color indications "Stop" and "Proceed" north and south, and two color indications "East and West." Such a scheme would necessitate locating the control towers at or very close to the street intersections and having signals for east and west traffic at each cross street.

Regarding the method of control of these signals, at present a traffic policeman is employed in each of the five towers. With three shifts, there would be required fifteen men for this duty. A great saving in operating costs would result if the signals of all these towers were controlled from one location, which would mean only three men instead of fifteen. The remote control of color light highway traffic signals is perfectly possible. For the remote control of these signals a total of only two wires the length of the Avenue would be required. These circuits are very flexible and by their use the signals could be operated from any one of the five towers. If, due to circumstance, it became necessary to cut one or more towers out from the rest and operate them locally, it could be so arranged by the throwing of several switches. These circuits are adaptable to either direct or alternating current.

DISCUSSION

J. H. Friedlander: Your Chairman has asked me to say a few words in respect to the Traffic Tower. I am a great believer in an architect doing his talking with a pencil; in other words, what he produces must stand for the message he has to convey to the public. But there is one thought which I may appropriately dwell on at the present time and that refers to the entire field of architectural expression, namely that a design or an invention in architecture must be the logical expression of the condition inherent on the problem.

The Traffic Tower problem was an unusually interesting one because its solution was based on novel conditions brought about by the enormous increase in recent years of vehicular traffic in New York. This new situation was without precedent, nothing like it had been known before and it was useless to attempt to fall back on the usual architectural traditions which had come down to us through the centuries. There were no traffic towers in England, or France or Rome or even Venice from which to seek "inspiration." Thus it became apparent that the only method to adopt was to take the traffic conditions as they existed to-day and clothe them architecturally.

A clear view up and down the Avenue was at all time essential; therefore, the open form of tower was used and not a solid shaft. It was necessary to build a number of towers; therefore, from the standpoint of economy bronze was adopted so that all could be cast from one mold. It was extremely important to do away with the unsightly ladder giving access to the booth. But the legs of the tripod sloped similarly to a ladder, and so the latter became an integral part of the design.

Thus the tower came into being, a symbol of new conditions architecturally expressed. And herein to my mind lies the difference between an architect and an archaelogist. The former, trained in the technique of his profession, allows the special conditions of the problem to evolve their own architecture. The latter brings forth from his library a photograph of some old-world structure, attempts to jam the same special conditions of the problem into it and reproduces it for the edification of the public. One is architecture, the other is archaeology.

I am convinced that if this vital principle be followed we need not despair of finding, at no distant date, new formulae in architectural expression which may exactly interpret the mode of life and thought of the present era in this country.

In respect to the illumination of the Tower, I am greatly interested in developing it along these lines. I have a mental picture of the effect I should like to obtain for the Towers and would therefore welcome any suggestion at any time that you would care to make, for I have always been of the opinion that the lighting or illumination of architecture helped to contribute as greatly to the ultimate decorative effect as did mural painting and sculpture, and that consequently it should be ranked with them as contributing factors in the successful and final result.

S. W. TAYLOR: At the risk of fatiguing the audience, I would like to call attention to one remark made in the very interesting address by Mr. Warner, that is the economical element might enter into the control of traffic on Fifth Avenue by substituting automatic signals in place of the humanly controlled signals as they are to-day. They are in a certain sense automatically controlled from the central tower at 42nd Street.

A psychological phase of the control of traffic which is transcendent to the economic one, I think, is the presence of the policeman in the tower. His presence there impersonates the tower, so to speak, if I may use such a coinage; that tower is thereby transmuted into a living human factor by the presence of a policeman in it.

If these towers were merely automatic signals the ordinary driver, particularly the taxi man, many of whom are known as "buckers" would realize there was no policeman in the tower to telephone to the next tower that he had cut a corner or taken off a piece of the isle of safety with his hub or some other part of the machine, and he would become so careless or ruthless that this would get to be a regular performance.

The fact that we have fifteen policemen on these three platforms instead of only three, is, under the circumstances not to be considered. I think the matter of men is entirely subordinate to the larger economic element of safety to human life, limb and property.

H. V. BOZELL: I wonder if there is anyone here who is familiar with the system which I understand is now in existence on Woodward Avenue in Detroit?

JOHN O'BRIEN: That is similar in a great degree with Fifth Avenue.

H. V. BOZELL: I was under the impression that there were signal lights suspended in the center of the crossings so that signals were given to the side streets as well as to Woodward Avenue.

JOHN O'BRIEN: I think that is true. That will be the purpose of the permanent erection on Fifth Avenue; what is there now was never intended to be permanent but to find out if the system was practical and it has been found to be practical.

G. H. STICKNEY: Whether or not the system of signal lights used in Fifth Avenue is the best that could be devised, no one who has watched the handling of the traffic before and since its inauguration, can doubt its success. Not only has the movement of traffic been accelerated, but the pedestrian finds it easier to cross the street. New York is to be congratulated upon having a Deputy who had not only the initiative to propose the plan, but also was willing to support it by his own financial resource.

The use of light signals for traffic control is not new, and it is perhaps surprising that the plan was not urged earlier by an engineer. Undoubtedly, the resulting success is largely due to the long section of street which is operated as a unit. I am inclined to think that another important factor is the insistent demand on the attention exerted by the high power beams of light.

Regarding the location of signals, it would appear that, while the placing of towers in the centre of the street may introduce an impediment to traffic, it does make the signal particularly conspicuous to anyone driving on Fifth Avenue.

No mention has been made of the character of light distribution, intensity of beam and the wattage employed. Such information would be interesting.

Mr. Macbeth's remarks to me raise the natural query as to whether any trouble has been encountered in the interpretation of

signals by color-blind people. I believe nearly ten per cent of the male population are supposed to be more or less color-blind, and that red and green are more likely to be so confused than any other colors. On railroads, such troubles are guarded against by examinations for this defect, but nowhere, so far as I know, are automobile drivers required to qualify in this respect.

Floodlighting the ornamental towers would not only enhance their appearance, but also assist drivers in avoiding the structures. On the other hand, the effectiveness of the signals depends upon making them stand out in contrast to their surroundings, so that floodlighting, especially of the upper part of the structures, should not be too powerful. Furthermore, any excessive glare from floodlights must be avoided.

I have seen the signal equipment that was tried out in Cleveland. While I am not certain, I have the impression that they were not particularly effective. They certainly did not seem very conspicuous, either as to location or power of beam. Perhaps Mr. Magdsick could tell us more about them.

I believe that the Fifth Avenue installation indicates what can be done with signals which insist upon being seen.

H. V. BOZELL: The reason I brought up the question of watts and candlepower particularly was because there is a signal light over on Broadway at Times Square and if you do not know exactly where it is, it is very difficult to make it out against the bright background up around 47th and 48th Streets. I have been wondering if there have been any experiments performed with reference to determining the brightness of the traffic control light on Times Square because of the extremely bright background behind it.

Another question occurred to me: I wonder why the traffic tower at 37th Street has the lights in a vertical column instead of a horizontal row as most of the others. Is it merely an experiment or is there a reason for it?

JOHN O'BRIEN: That is simply an experiment in different positions with light. That light was not really needed except for the purpose of carrying down to 34th Street.

H. W. GRIFFIN: One point has not been raised here, the question of lenses. I understand that the lenses which have been used in these lights have been simply colored glass. I can say that by the use of lenses such as are used on the railroad signals, you would get a real color and a dense color that would show up, particularly at night, against any signs. I have noticed that the lights are very poor, especially the green, and I would like to know how they are colored.

JOHN O'BRIEN: That was true at first but it is not now. You will notice to-night, for instance, if you are over there, that the lights are much brighter than they were some time ago. Recently they have had new lenses. Dr. Harriss is experimenting with new lenses and I think he has discovered something along the line of what he wants. You will notice both day and night that the lights are much clearer and better than they were at first. On Broadway the light is simply colored glass.

H. W. GRIFFIN: I understand they use 400 watts behind each one.

JOHN O'BRIEN: I guess you might add a little more, as there are seven lights on each tower on Fifth Avenue and there is a 125-watt bulb used in each light, so you can see you are conservative in your estimate. That I think can be reduced considerably by using proper lenses and reflectors. I think the wattage can be reduced in the permanent construction.

E. A. WARNER, JR.: In some of the early experiments with light signals on the railways in this country very high candle-power lamp bulbs were used in an endeavor to obtain a daylight beam of very high intensity. It was found, however, that at night the power of these beams was so great as to practically blind the engineers. For this reason the Pennsylvania Railroad at first adopted a scheme of reducing the voltage on the lamps at night to cut down the power of the light signal indications. This scheme, however, was rather a costly one in view of the fact that many of the signals were outlying and the reduction in voltage had to be effected by means of relays and long line circuits. It was therefore decided to adopt a lower voltage, the same voltage being used both day and night. For the Fifth Avenue signals or in fact for any city traffic signals the question

of undue brilliance at night would not play so important a part because the illumination of the surrounding buildings and signs at night would more nearly approach ordinary daylight conditions than would be the case on the railroads in this country.

H. W. GRIFFIN: There is another thought which may interest these gentlemen. I have had considerable signal lighting experience on railways and as regards illuminating the tower, I do not believe there would be trouble at night if the proper lenses and the proper wattage lamps were used, for there would then be no question but what the red, green, or yellow would be displayed in spite of practically any illumination that you could put on the tower. I feel that way because of the indications we get under sunlight conditions. One other gentleman spoke about yellow being poor. We find of the three colors, red, green and yellow, which we display; that the yellow has the longest range, the red next and the green the shortest range, all with the same amount of wattage behind the lamps.

S. E. DOANE: This is all very wonderful I can not add anything to the story of the Fifth Avenue traffic control lights. We know, of course, that lights have been tried before, one way or another, but this is the first real workmanlike system that I have seen.

The gentleman asked about the Cleveland control by colored lights. They were not large enough and they were on the corners of the streets, because the streets were so narrow they could not be anywhere else, and the people on the side streets could not see them. I notice in New York that if you are half way between the towers on the side street that you have to drive your machine out beyond the building line in order to get a view of the signals. I think it would be better if these lights were paralleled by lights on the side street so that people coming out of the side streets would know whether or not they should approach the corners.

There is another point which might be useful in controlling traffic in the city of New York. Some time ago when I was in Paris they cut out the headlights on the automobiles in the brightly lighted districts and left the tail-lights on. That would seem to be a very useful idea because sometimes the lights on a machine backing up in front of you interfere with a view of the signals.

I have also noticed that traffic in New York is not regulated the way it is in London. In London they regulate traffic so that each vehicle passing along the street keeps in its path. For instance, supposing there were three lines of traffic going up Fifth Avenue and three coming down. The bus and heavy traffic would keep near the curb and the lighter and faster traffic near the center.

I was driving in London some years before the war when I was a little green on driving over there. I was driving in the line next to the curb, and seeing a chance to slip out, I slipped out to the left and finally pulled back into the second line again. A bobby down the street called me and said, "I see you are a stranger. Take the line that you intend to stay in and stay in it." I think a great many of the accidents are due to the fact that we find machines dodging out from behind another and catching pedestrians who do not expect that there is a rapidly moving vehicle trying to get in front of the other

It seems to me that we ought to have some control for passing up and down the street and that we might just as well pick our line and stay in it. I think if we would all do that, it would help the regulations on Fifth Avenue.

Speaking of traffic regulation in other cities, in Columbus, Ohio, they have the booth on the ground and have a traffic light on the top of the booth with a semaphore. As I remember the Woodward Avenue signals (and at the time I did not think of them particularly) they must have been copied after the New York signals. The signals used in Cleveland many years ago were those copied after St. Paul.

In closing I would like to have Mr. O'Brien tell us whether they are considering the placing of booths on the corners or in the centers of the streets and also if the signals are to be parallel with the side streets.

JOHN O'BRIEN: Mr. Doane has just raised a point about having the lights shown on the side streets. Now that of course is absolutely true and they are intended to be that way when the towers are permanently established. As I said a little while ago, the towers on Fifth Avenue are only temporary ones, and when

the permanent towers are established, the side streets will be able to see the light at the time it shows on the tower. That is intended and it would not be complete unless that was put into effect, because a view is necessary to the driver on a side street so he may know what is going on in the other thoroughfare before he gets to the building line of that particular street.

Mr. Doane also raised the point about the necessity of keeping in the established lines of traffic. Of course the traffic in London, Paris and in other cities differs considerably from the traffic in New York. We have possibly a greater volume of traffic and more busy people in this city than there is in any other city in the world. Take the men and women who are riding in their cars; they are busy and want to get some place and they go down Fifth Avenue and turn into some side street and unfortunately we can not seem to be able to get around that.

Now I believe left-hand turns should be discontinued as far as possible or eliminated, but still when you do that, you may possibly be infringing on the rights of some business people, which we do not want to do. We do not want to be in the position of interfering and hampering business, but we want to be helpful to business of the city and for that reason we have to try to do many things that our better judgment might dictate otherwise.

Taxicabs have been spoken about. Of course, they are a nuisance in a great many ways. They run, as we might say, wild, but still as far as accidents by taxicab drivers are concerned; there are less accidents in comparison with the number of taxicabs in the cities than there are with an equal number of other vehicles. For those reasons, we can not be too hard on the poor taxi driver. We try to hold him down and he needs to be held down, but yet he is what I suppose we might call a necessary evil. I think if you were standing on a wet corner some night, Mr. Doane, you would just wish to see a taxi come by with nobody in it.

I think Mr. Doane is perfectly right as far as pedestrians are concerned. They have to be educated up to the point where they will use reasonable judgment in crossing streets. The Police

Commissioner of the City of New York, as some of you know, has absolute authority as far as the promulgation of rules and regulations for the control of vehicles is concerned but he has no such power over pedestrians. The law does not give him that power and we have tried and are trying to get that power and I hope some day we will. I have said this over and over, that if we had the control over pedestrians that we have over the drivers of vehicles, then we might be able to make better progress.

Of course the people here are so busy and so engrossed in their everyday activities that they have no time at all to look after their safety in the streets; they just simply *go;* they want to get there as quickly as possible. They are thinking about some deal or some business they have to transact and walk out in the middle of the street and think they are on the sidewalk.

When we get them up to the point where they will submit to education, that will help us to accomplish the purpose we hope to accomplish and we will make some headway.

ABSTRACTS

In this section of the TRANSACTIONS there will be used (1) ABSTRACTS of papers of general interest pertaining to the field of illumination appearing in technical journals, (2) ABSTRACTS of papers presented before the Illuminating Engineering Society, and (3) NOTES on research problems now in progress.

ILLUMINATION INTENSITIES CHOSEN FOR READING

BY M. LUCKIESH and A. H. TAYLOR*

One of the interesting questions of lighting at the present time is "What is a satisfactory intensity of illumination?" Of course in general the answer depends upon many factors such as the kind of visual work, the distribution and the spectral character of light, the brightness and the color of surroundings, the visual apparatus and the physical state of the observer, etc. In a recent extensive investigation[1] this was one of the problems studied and since reporting the results, the research has been extended. This brief note is confined to the results of the choice of illumination intensity for reading black print on white paper.

In the original investigations several kinds of type were used on white and on gray paper and twenty to twenty-five observers were employed. The investigation of desired illumination intensities for reading black type on white paper has been considerably extended and the results are herewith presented. The lighting units were above and slightly to the left and rear of the observer so that the direction and distribution of light were ideal for reading. The surroundings in the visual field were of a medium buff and the reading material was that of the *Saturday Evening Post* or of a similar nature.

The observers were instructed that the object of the test was to determine the intensity of illumination which appeared to be most satisfactory for continued reading. In other words, the choice was not to be that intensity with which it was just possible to get

* Laboratory of Applied Science, Nela Research Laboratories, Nela Park, Cleveland, Ohio.

[1] *Jour. Frank. Inst.*, 192, 1921, p. 757.

along but rather one which seemed comfortable and desirable. The observer first read for four minutes under an intensity which was selected by the experimenter. After four minutes and each succeeding four-minute interval, the observer was asked to adjust the illumination intensity to suit himself. Shutters on the lighting units were arranged to be easily manipulated by means of pulleys and belts so that the intensity of illumination on the reading matter could be varied gradually from zero to a maximum or vice versa. Other details of the experimental method may be obtained from the paper referred to.

TABLE I.

THE MEAN INTENSITIES OF ILLUMINATION CHOSEN BY A GROUP OF OBSERVERS WHEN DIFFERENT MAXIMUM INTENSITIES OF LIGHT FROM MAZDA C LAMPS WERE AVAILABLE.

Maximum available illumination intensity (foot-candles)	Mean chosen intensities, (foot-candles)			
	(Curve A) From open position of shutter	(Curve B) From closed position of shutter	(Curve C) Average	Per cent maximum
8	5.1	3.3	4.2	52.5
30	12.7	8.3	10.6	35.6
45	18.8	13.5	16.1	35.8
65	27.7	18.9	23.2	35.8
100	48.2	23.6	35.8	35.8

The mean results obtained with light from gas-filled tungsten (Mazda C) lamps for the large group of observers are presented in the table for maximum available intensities from 8 to 100 foot-candles. The mean intensities chosen when the illumination was reduced from the maximum available to the chosen intensity are presented in the second column. The mean intensities chosen when the illumination was increased from zero are presented in the third column. The fourth column consists of the averages of the values in the second and third columns. The last column consists of the chosen intensities in percentages of the maximum available intensities; that is, of the values in the fourth column divided by those in the first column.

As was to be expected the chosen illumination intensitity in a given case was less when the illumination intensity was increased from zero than when decreased from the maximum. It is especially interesting to note that the illumination intensity chosen in-

creased with the maximum available and that the average value was about 36 per cent of the maximum available intensity excepting for the lowest value of the latter. Furthermore it is interesting to note the striking uniformity of these percentages (last column). The results indicate more than a well known vagary of human nature for they show that with good lighting conditions, the intensity of illumination chosen increases with the maximum available. The results appear to show that the intensity of artificial illumination can be very much larger than that commonly used, without producing discomfort. (Of course we know this from experience with the high intensities of natural light but the public is not acquainted with foot-candle values). Therefore, if high intensities of artificial illumination are desirable for other reasons, such as for the stimulation of the worker and for allied reasons which make for greater production, the limit of artificial illumination intensities under good lighting conditions has not yet been reached at 48 foot-candles.

None of the observers were particularly familiar with illuminating engineering and none were instructed in regard to the underlying motive for the investigation. Why they did not always choose the maximum appears to be accounted for by their assuming that the desired illumination intensity was somewhere within the range available.

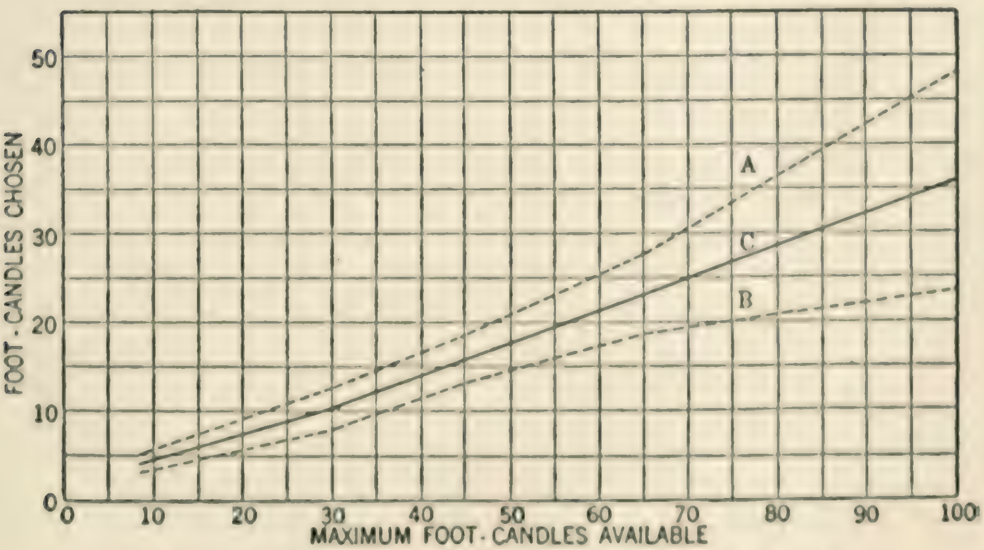

Fig. 1.—The curves A, B and C, are plotted from data in Table I.

The values in the second, third, and fourth columns are plotted in the Figure 1.

Owing to the widely different spectral character of the light from the mercury arc as compared with the continuous spectrum of the light from the tungsten lamp the same investigation was carried out for mercury-vapor light with the same observers up to a maximum available intensity of 45 foot-candles. It was found that the average observer desired 5 to 20 per cent more illumination from the mercury arc than from the tungsten lamps. The authors are at a loss at the present time to account for this but the latter results are not necessarily inconsistent with that previously published by one of them in regard to the effect of spectral character of light. In fact, the results for the mercury arc light seem to serve chiefly to emphasize the extreme complication of the phychophysiology of vision.

SOCIETY AFFAIRS

SECTION ACTIVITIES

NEW YORK

Meeting—April 20, 1922.

The New York Section met on April 20, 1922 at the Engineering Societies Building. Mr. P. Schuyler Van Bloem of the Viking Sign Company of New York presented a paper, "A Survey, Comparison and Classification of Indoor Electric Signs," which was accompanied by a demonstration of apparatus. Mr. C. A. Atherton of the National Lamp Works of Cleveland, Ohio gave an extemporaneous talk paralleling the above subject but confined to outdoor signs. An interesting discussion followed the presentation of the papers, and the meeting was attended by seventy-five members and thirty guests.

PHILADELPHIA

Meeting—April 11, 1922.

At the April meeting of the Philadelphia Section held at the Engineers' Club, Dr. Howard Lyon, physicist, Welsbach Company of Gloucester, N. J., gave a paper, "Some Principles of Gas Lighting." Dr. Lyon first spoke of the prehistoric methods of obtaining fire and light, and then traced the development of various illuminants to the present mantle for gas. He described the physical and chemical composition of gas flames and the effects of using mantles of different composition. The paper was illustrated with lantern slides and demonstrations with gas flames and mantles. A lengthy discussion followed.

The attendance at the meeting was eighty members and guests, and fifteen members attended the dinner at the Engineers' Club prior to the meeting.

Meeting—May 9, 1922.

The Philadelphia Section met for the May meeting at the Engineers' Club. A paper, "The Pullman System of Railway Car Lighting," by Mr. Ernest Lunn, electrical engineer, Pullman Company of Chicago, was read by Mr. A. H. Gerald. A complete account of the lighting in the cars, as well as the method of generating electricity and its control, was given in the paper, which was illustrated by means of lantern slides. A general discussion was held and about thirty-five members and guests attended the meeting.

CHICAGO

Meeting—March 23, 1922.

At the meeting of the Chicago Section held in the rooms of the Western Society of Engineers on the evening of March 23, Mr. Ward Harrison, National Lamp Works of Cleveland, presented a paper, "A Method for Determining the Acceptability of Luminaires from the Standpoint of State Laws." He had on hand a demonstration apparatus for showing the effect of raising and lowering the luminaires, together with the variation in color from different sizes of globes. Considerable discussion followed, as everyone was interested in the simple method of classifying luminaires.

Meeting—April 25, 1922.

A joint meeting of the Chicago Section with the Illinois Society of Architects was held at the Art Institute of Chicago on April 25, 1922. Mr. A. J. Sweet, consulting engineer, and Mr. H. W. Bogner, architect, spoke on the general topic "Lighting the Milwaukee Art Institute."

The work described by Messrs. Sweet and Bogner was a splendid example of the possibilities in lighting effects ob-

tained by close co-operation between the architects and illuminating engineers. Messrs. Sweet and Bogner gave very careful study to the fine points in the art of illumination and carried them out throughout the Milwaukee Art Institute at an extremely low initial and operating cost. Slides of all rooms were shown and there was considerable discussion by architects present, which showed a decided interest on their part in the art of illumination.

The attendance was over one hundred members and guests.

CLEVELAND

Meeting—April 21, 1922.

A joint meeting of the Cleveland Chapter with the Cleveland section of the Society of Automotive Engineers was held on April 21, 1922.

The groups assembled for this meeting at Nela Park at 3:30 in the afternoon for a trip through a miniature lamp factory, a miniature bulb factory and a large lamp factory. The members of both societies were entertained at dinner at Nela Park. The evening meeting was called at 7:30 P. M., when Mr. H. H. Magdsick presented a paper on "Motor Vehicle Lighting."

Mr. Magdsick discussed the many factors affecting the voltage supplied at the lamp socket under service conditions and translated the resulting voltages into terms of candlepower. He pointed out the desirability of equipments which maintain constant voltage over those which maintain constant current. Socket construction was discussed at length from the standpoint of good lighting. He presented test data on many cars, showing voltage drop in various portions of the circuit, and gave tables of maximum, minimum and average drop as found. Values of voltage drop which might be considered good practice for various portions of the circuit were also presented.

A particularly interesting feature of the paper was the demonstration of light control by various reflectors and cover lenses showing many experimental forms and a number of commercial equipments, with particular reference to the headlighting laws and codes. The paper was enthusiastically received and was followed by an interesting discussion.

The attendance was approximately sixty.

COUNCIL NOTES

ITEMS OF INTEREST

At the meeting of the Council on May 11, 1922, the following were elected to membership:

Three Members

CHARLES C. MUNROE,
Chief of Lighting Sales Staff,
Detroit Edison Company,
Detroit, Michigan.

JOHN T. SCOTT,
Engineer Sunbeam Lamp Division,
Canadian General Electric Company,
Toronto, Ontario, Canada.

WILLIAM H. ZORGER,
Physician—Eye, Nose and Throat,
President Zorger Lens Company,
5 Main Street,
Champaign, Illinois.

Eleven Associate Members

H. ALDEN BARNES,
Illuminating Engineer,
Wheeler Reflector Company,
156 Pearl Street,
Boston, Mass.

ROBERT BIDDLE,
President,
Biddle-Gaumer Company,
3846-56 Lancaster Avenue,
Philadelphia, Pa.

HERMAN COLEMAN,
Penn. Gas & Elec. Supply Co.,
26 N. 7th Street,
Allentown, Pa.

EUGENE W. COMMERY,
Engineer of Light Utilization,
Laboratory of Applied Science,
National Lamp Works,
Nela Park, Cleveland, Ohio.

MICHAEL A. DE CHATELAIN,
Professor of Electrical Engineering,
Petrograd Polytechnic Institute,
Lesnoy,
Petrograd, Russia.

JOSEPH E. FRECHIE,
Joseph E. Frechie & Co., Inc.,
27 N. 7th Street,
Philadelphia, Pa.

CHARLES E. JOHNSON,
Lighting Specialist,
Westinghouse Elec. & Mfg. Company,
811 Van Nuys Bldg.,
Los Angeles, California.

HUBERT H. PFEIL,
Salesman,
Macbeth-Evans Glass Company,
1722 Ludlow Street,
Philadelphia, Pa.

HARRY HOWELL SMITH,
Vice-President,
W. B. Catlett Elec. Company, Inc.,
114 West Grace Street,
Richmond, Va.

GEORGE V. STRAHAN,
Designer of Lighting Fixtures,
Mitchell Vance Company, Inc.,
507 W. 24th St., New York, N. Y.

E. L. THOMPSON,
Illuminating Engineer,
George Cutter Works,
South Bend, Indiana.

CONFIRMATION OF APPOINTMENTS

The appointment of the following committee members were confirmed.

As members of the General Convention Committee

Frederic A. Boss
Charles S. Davis
W. J. Drisko
Guy C. Emerson
Henry K. Morrison
Theo. R. Piser
Fred H. Sargent
Fred H. Smith
E. E. Stevens
R. M. Topham
R. F. Whitney

As members of the Committee on Tellers

A. C. Dick, Chairman
E. L. Bradbury
Arthur Miller
A. S. Turner
S. W. Van Rensselaer

As member of the Committee on Membership

W. T. Blackwell

As member of the Committee to Co-operate with Fixture Manufacturers

Samuel Snyder

As delegates to Conference on Colors for Traffic Signals

Louis Bell
M. Luckiesh
C. H. Sharp
G. H. Stickney

COMMITTEE REPORTS

Progress reports were presented from the following: Committee on Editing and Publication, Committee on Membership, Committee on Sky Brightness, Committee to Co-operate with Fixture Manufactures, Committee to Prepare Bulletin on Residence Lighting by Gas, Committee on Advertising, Committee on Education, and Committee on Papers.

NEWS ITEMS

CONVENTION HEADQUARTERS AT BOSTON

The sixteenth annual convention will be held in Boston, on September 25, 26, 27 and 28, 1922 at the Hotel Vendome which has been selected as the convention headquarters.

The Hotel Vendome is located on Commonwealth Avenue, at Dartmouth Street, the City's most attractive boulevard. Situated one block from Copley Square, famous for the architectual beauty of Public Buildings and Churches surrounding it, two blocks from the Back Bay Stations, and one block from surface cars and the New Boylston Street Subway.

In this district are numerous hotels, clubs and buildings that will be of interest to the Society members.

GENERAL OFFICE NOTES

Copies of the following issues are desired:

Vol. XIV, No. 2, Mar. 20, 1919.
Vol. XIV, No. 9, Dec. 30, 1919.
Vol. XV, No. 7, Oct. 10, 1920.
Vol. XVI, No. 3, April 30, 1921.
Vol. XVI, No. 7, Oct. 10, 1921.
Vol. XVI, No. 8, Nov. 20, 1921.

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PERSONALS

Mr. R. B. Burton of the Duplex Lighting Works of G. E. Co., was recently elected president of the Board of Education of Mount Vernon, N. Y., of which he has been a member for the past year.

Dr. Ernest Fox Nichols, who has been spending some time in Honolulu, returned on May 15, 1922 to his work as Director of Pure Science in the Nela Research Laboratories of the National Lamp Works of the G. E. Co., at Cleveland, Ohio.

The American universities selected as their representative to the French University Administration for the first year Dr. Arthur E. Kennelly, past-president of the Illuminating Engineering Society, professor of electrical engineering at Harvard University and the Massachusetts Institute of Technology. He has met with great success in his undertaking in France, and in addition to lecturing before numerous French technical schools was assigned by the French educational authorities, through M. Petit Dutaillis, minister of public instruction in France, to spend several weeks at the Universities of Paris, Grenoble, Lyons, Marseilles, Toulouse, Bordeaux, Nancy and Lille, giving in each a course of lectures, some technical and others of a more general character.

Mr. G. Bertram Regar, on May 25, presented a paper, "Adequate Artificial Illumination as a Means of Improved Production and Protection to the Industrial Worker," before the Fifteenth Conference of Industrial Physicians and Surgeons at Harrisburg, Pa., held in conjunction with the Ninth Annual Convention of Governmental Labor Officials of the United States and Canada.

ILLUMINATION INDEX

PREPARED BY THE COMMITTEE ON PROGRESS.

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TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

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The Distinctive Character of the Illuminating Engineering Society

IN THE EXERCISE of its constitutional function of advancing the theory and practice of illuminating engineering and of disseminating knowledge relating thereto, the Illuminating Engineering Society is under obligation to bring to bear a diversity of viewpoints so varied as to lend to its activities a distinctive character. It may ally itself with ophthalmologists in the study of the functioning of the human eye, or with architects in the study of the artistic requirements of lighting, or with commercial organizations in the promotion of improved lighting practice. The ophthalmologists with whom the Society co-operates may be interested solely in the eye; the architects may be interested solely in their art, or the commercial organizations may be interested in the promotion of their business—but the Society, while sympathetically inclined toward all movements which are for the good of the public, is interested primarily in promoting the purpose for which it exists, as stated above.

Whereas the ophthalmologists as such specialize on the eye, the Society, when dealing with the function of the eye, approaches the subject from the point of view of adaptation of lighting to ocular requirements. Whereas architects are interested in structures and their adornments, the Society in dealing with architecture is interested in adapting lighting to artistic requirements. Whereas commercial organizations as such are interested primarily in promoting their business, the Society in co-operating with them is seeking to bring about the improvement of lighting for public advantage. From the Society point of view its func-

tion cannot be fulfilled without the co-operation and assistance of such specialists as ophthalmologists, architects and those engaged in the lighting industry. These purposes are not well served unless the point of view of the oculist and the architect is brought to bear when dealing with lighting activities fostered by commercial organizations, nor are they served unless the co-operation by commercial organizations is enlisted in bringing about the improvement of lighting which is necessary to a realization of the ideals of both the oculist and the architect.

In the breadth of view imposed by the very nature of the problem which it seeks to solve, the Society is distinctive among other organizations.

Preston S. Millar

REFLECTIONS

Boston—1907, Swampscott—1922

AFTER a fifteen-year interval, Boston has again been selected as the host for the annual convention of the Illuminating Engineering Society, during the last week in September.

The first convention of this Society was held in Boston in the then new Edison Building on Boylston Street, during Boston's Old Home Week, for which the city was elaborately decorated. There were in attendance 200 members and guests who were welcomed by the Governor of Massachusetts, Curtis Guild, Jr., and the Mayor of Boston, John F. Fitzgerald.

Mr. Charles L. Edgar, President of the Boston Edison Company, has accepted the chairmanship of the General Convention Committee, and associated with him are H. F. Wallace, Vice-Chairman, J. Daniels, Secretary, and many of the members who were responsible for the success of the first convention.

The New Ocean House, Swampscott, Mass., has been selected as convention headquarters in place of the Vendome Hotel at Boston. Situated twelve miles outside of Boston in one of the most exclusive sections of the North Shore, the hotel faces the wide expanse of the Massachusetts Bay and fronts upon a broad curving sandy beach. The splendid bathing beach makes swimming a popular diversion. Other entertainment consists of riding, putting, croquet, tennis, motor boating and fishing.

Nearly all American institutions, literary, religious, industrial and historic, had their beginning in or around Boston. Trinity Church, founded in 1828; New Old South Church; Boston Public Library; Mechanics Building; Christian Science Church; Horticultural Hall and the Museum of Fine Arts are points of interest to visit.

By crossing the Charles River the Massachusetts Institute of Technology buildings are seen and, farther on, one finds Harvard and Radcliffe Colleges; Washington Elm, under which Washington took command of the Continental Army; Statue of John Harvard; Black Horse Tavern, where the Committee of Safety were spending the night on April 18, 1775; and Cooper's Tavern, in which two Americans were killed by the British on April 19, 1775.

Lexington should be visited by every patriotic visitor to Boston for here we find Munroe Tavern, used by Earl Percy in 1776 as headquarters; Lexington Green, scene of the Battle of Lex-

ington; Parkman Boulder, where the minutemen were lined up; and in Concord, the Old North Bridge, where the minutemen made their stand.

Returning to Boston, we find scenes of renowned historic interest such as the Old South Meeting House; Home of Ann Hutchinson; Site of Boston Massacre, 1770; Old State House, 1713; Faneuil Hall, "Cradle of Liberty;" Home of Paul Revere; Old North Church; Christ Church; The Constitution; Charlestown Navy Yard; Bunker Hill Monument; Massachusetts State Capitol; Boston Common; and Boston Public Garden.

The program of entertainment for the ladies will undoubtedly include an automobile trip along the North Shore to Gloucester, and visits to the distinctive shops for women for which Boston is so famous. For those who play golf, several very good courses will be open and the practical set of papers to be presented this September should make this convention very interesting and profitable to members and their guests.

Street Lighting and Traffic Accidents

IT IS RATHER startling, though it should not be surprising, to learn that 17.6 per cent of all of the deaths due to automobile accidents last year were caused by insufficient street illumination. An estimated cost in dollers only, of these 567 deaths is over 54 million dollars, while the total street lighting bill for the country was only 50 million dollars. It is like a man who is paying more for fire losses in his factory, than he is for insurance. It is a hundred times worse than that because of the enormous responsibility that is involved in the deliberate sacrifice of human life, although of course, a lack of information and realization of the true relative values makes the responsibility less definite.

The figures upon which these costs are based are the result of a collection of data in 32 cities with a combined population of over 7,000,000 people and the statistics covered a full year's record. The complete discussion of "Street Lighting and Traffic Accidents" by Earl A. Anderson and O. F. Haas appeared in the TRANSACTIONS of the Society for November 20, 1921.

Use of Light as an Aid to Aërial Navigation

IN The *Illuminating Engineer*, Vol. 15, No. 2, Mr. L. F. Blandy has written an interesting paper on the use of lights on airships and in aërodromes and of the construction of aërial lighthouses. In view of the high speed at which airships now travel the lights attached to them need very careful design. The problem of sufficient intensity with absence of glare is not easy to meet. The

lighting of the quarters for passengers and crew on board aircraft is also a vital matter. Aërodrome lighting presents a variety of aspects, including the use use of light to indicate the presence of obstructions and the lighting of the actual ground of the aerodrome.

One of the most interesting sections of the paper is that dealing with aërial lighthouses and local pilotage lights. The former indicate the route to distant travelers while the latter act as a guide to aviators approaching their destination. Both classes of lighting have been studied with care, and the collected data indicate that considerable progress has been made.

Architectural Values in Illumination

PERHAPS the most critical task in arranging the illumination of a public building is to adjust the character of the lighting and the fixtures which contain it to the general architectural requirements. In this matter more than anywhere else has illumination suffered from bad precedents, since in very many instances the lighting of a building in the past has borne no relation whatever to the architectural harmony of the whole. Lighting fixtures have been regarded too often as things to be judged alone and not in company with their surroundings. Hence it has happened many times that fixtures beautiful in themselves considered merely as objects of art have been put in very inappropriate situations, or, on the other hand, fixtures possessing no particular merit have been thrust into service from merely utilitarian motives. From long custom and a slavish regard to ancient precedent, however bad, people have come to tolerate inharmonious treatment of lighting fixtures. For example, the exaggerated pendent lights of the mosque of St. Sophia, decorative enough individually but hanging from absurdly long and conspicuous rods, have served as a motive for an infinite amount of bad church lighting.

A decidedly interesting case of modern lighting in which the fixtures have been worked into the general design of the structure with usually good results is considered in this issue. The main problem was lighting a big arched arcade, with a gallery floor filled with stores and shops as well as the ground floor below. The method taken to obtain powerful and effective lighting without throwing glare into the gallery was a very effective extension of cove lighting at the cornice. The coves served as housings for silvered-mirror reflectors which did the actual work, and the contour of the cove was such as to provide effective light without exposing the sources. Another unusual feature of the illumin-

ating design was the provision for uniform window lighting while also allowing color effects to be freely used when especial displays were necessary.

Throughout the offices, which take up a considerable part of the arcade in its upper levels, indirect lighting units were installed to provide a uniform equipment easily kept up. Strictly speaking, the fixtures have a material similarity to some semi-indirect fixtures in that a diffusing glass shield on the under side of the fixture is given surface brilliancy high enough to avoid having a dark spot against a bright ceiling. Fixtures of this character are worth more study than has usually been given them, for they seem to form a class almost by themselves, as distinguished on the one hand from pure indirect fixtures with opaque reflectors and on the other from the more or less dense bowls in which the transmitted light is a somewhat important factor in the general illumination.

Gradually we are learning how to adapt modern fixtures to modern needs, and eventually the result will be a class of fixtures artistic, sound and practically useful. But we think these will, on the whole, be products of the evolution of the twentieth century and not adaptations from the sixteenth or seventeenth. These last have an undeniable artistic value in the period decoration of suitable rooms, but the big needs of modern buildings demand something more nearly to scale. The real problem is not how the Renaissance artists used candles, but how Cellini or da Vinci would have treated a single source of a thousand candles to the glory of his art.—*Electrical World,* July 8, 1922.

Economic Aspects of Defective Vision

EVERY CHILD in the United States is entitled to a chance to see correctly and recent statistics show that every child does not have this opportunity.

Recent surveys among children in the schools and among the workers in the industries of several large cities have revealed alarming conditions of vision. It has been found that defective vision is a large element of retardation among the children in the schools. Recent estimates indicate that approximately 25 per cent of the school children in New York City have defective vision.

The schools are a particularly fertile field for eyesight conservation. In the rural communities particularly, very little provision is made for the care of the children's eyes or for the proper lighting of the school rooms. In 1,262 rural schools reporting from eighteen different states eyes are not tested

in 76 per cent of them. Reports from different states where school children's eyes have been examined show that a large number of them had some eye defects needing correction. When we note that of the 100,000 school children of New York City public schools who failed to pass their examinations last year 50,000 were found to be suffering from eye defects needing attention we can well understand why some rural communities report that a number of their pupils are "retarded."

Teachers throughout the country should be trained to make certain simple tests of the eyes of the children under their care, to determine those cases which are manifestly below normal and in need of immediate attention. This would be of great assistance and would detect most of the extremely bad cases and thereby avoid much needless suffering as well as waste in the efficiency of our educational system.

It is significant that, with all the health work that has been done in schools, it is still true that a great majority of children in this country with defective vision have not yet received any intelligent care. Schools are not yet making sufficient provision for careful examination of pupils. Neglect with reference to vision is greatest in country schools.

As to the prevalence of defective eyesight in the various industries recent studies reveal some startling results. In the examination of more than 10,000 employees in the factories and commercial houses, 53 per cent were found with uncorrected faulty vision, 13 per cent had defects which were corrected, making a total of 66 per cent with defective eyes. In one manufacturing establishment over 70 per cent were found with eye defects. In another plant the following startling condition was discovered: Glasses worn and satisfactory, 8 per cent; glasses needed and ordered, 83 per cent; no glasses needed, 8 per cent. As an example of inefficiency and resulting waste, 20 per cent of the inspectors in a large factory were found to be unable to see *sufficiently well* to detect defects in the product they were inspecting. This is an intolerable situation and inexcusable when the remedy is so simple and inexpensive. There are 42,000,000 persons gainfully employed in the United States, of whom over 50 per cent are handicapped by defective vision or eye strain.

Investigations by the committee on the elimination of waste in industry of the American Engineering Council of the Federated American Engineering Societies showed that conditions of eyesight among the millions of the nation's workers were not unlike those found in the schools. This committee arrived at the con-

clusion that correction of substantive vision produces an increase in return that will pay for its cost. Frequency of substantive vision has been established by several carefully reported investigations among employees, especially in the garment industry. Goggles are not being used in hazardous employment. Improvement in lighting conditions is desirable in remedying defective vision in industrial plants. Human efficiency is more dependent upon good eyesight than any other sense. Nature allots the human machine a certain portion of nerve energy. Defective eyes demand extra nerve energy and must, of necessity, lessen the normal nerve supply. Waste of nervous energy directly diminishes human efficiency.

Looking at these conditions from a purely economic angle, one is appalled at the resulting waste of effort and the inefficiency of millions who daily contend with the handicap of faulty vision. Conditions like these have led the educators, manufacturers, engineers and economists to carry into every state an educational campaign for better vision.

What does this prevalence of defective eyesight mean in the store, the office, the factory, the bank and in every place of business? What does it mean to production? That is our big problem to-day, greater production at less cost. The nation must produce more and waste less. Full production and the reduction of waste to the minimum are only possible when the individual is normal physically. We have given more attention to the perfecting of machinery than we have to the correcting of physical defects in the individual. We have developed the mechanical and neglected the man. More consideration is needed for the human element, more attention to the physical fitness of the individual. There are comparatively few positions filled as well by cripples as by persons physically normal. Still, there are many people apparently normal and presumably efficient who are to some degree crippled by defective vision and, therefore, not as efficient as they should be. No physical defect contributes more directly to fatigue and inefficiency than eye strain, or is more responsible for waste of vitality, effort, time and material.

How can we be more efficient, how can we successfully compete with the cheaper labor and longer hours of employment in other countries? By correcting physical defects and so directly increase the efficiency and the productivity of the individual. Every manager should see to it that the eyes of all associated with him are corrected to compensate for defects. It will pay from a purely business standpoint being reflected in better service, fewer mistakes and higher standards.

PAPERS

A TEN YEAR ADVANCE IN THE ILLUMINATION OF SMALL STORES*

BY A. L. POWELL**

SYNOPSIS: During the ten years elapsed since the original survey was made, the art of illumination has become better understood, new forms of illuminants have appeared, many developments in lighting accessories have been completed, the standard of illumination has been raised about fifty per cent. The tungsten filament lamp of the vacuum type has been replaced by the gas-filled lamp, the 200-watt lamp having been put into use in nearly sixty per cent of the stores recently surveyed.

One of the most significant features of the paper is the departure from the open-bottom reflectors to the enclosing and the indirect types of luminaires.

The wattage consumed in these stores indicate the amount used is no more than that used in 1912, while higher intensities of illumination now prevail, the cost of electrical energy has been substantially reduced, hence the average storekeeper is getting more efficient illumination and now is paying less for it.

Typical lay-outs for various kinds and sizes of small stores are shown together with numerous illustrations. The subject of lighting show-windows is discussed and mention made of the effects obtained through the use of colored lights and spot-lights.

In 1912 the writer collaborated in an investigation of the lighting of the typical small store. The material gathered during this investigation was presented at the Fall Convention in Niagara Falls,[1] and gave rise to considerable favorable comment. Nothing especially novel was brought out in the paper, for to quote from the introductory paragraphs: "The purpose of this paper is not to present any new ideas on a particular phase of lighting * * * *. We know there are thousands upon thousands of small stores throughout the country, any of which are typical of its class. In the main, these are not of sufficient importance to be treated individually by an illuminating engineer. Therefore, if a set of approximate rules could be put in the hands of the central station or manufacturer's solicitor, with the aid of which he could intelligently design such lighting installations, a distinct step should be made in the advancement of the art of illumination* * * * It seems somewhat desirable to standardize the practice in small store lighting, and knowing that this can best be done by the method of averages, we proceeded to determine the present state of the art and to interpret the observed values."

* A paper presented at the meeting of the New England Section, Boston, Mass. May [illegible], 1922.

** Lighting Service Dept., Edison Lamp Works of G. E. Co., Harrison, N. J.

[1] Transactions, I. E. S., Vol. VII, No. 7, page 417—"Present Practice in Small Store Lighting with Tungsten Filament Lamps" by Clarence L. Law and A. L. Powell.

As a basis of that paper, over 800 ordinary small stores handling the principal classes of merchandise, were visited and the lighting features surveyed.

We felt that material of this character would be of service to the classes of members noted above, and so it proved, for to quote from two typical discussions after the paper was read, a central station man said: "This paper touches closer the class of illuminating engineering I am up against every day * * * *." Another, "This paper is very valuable to the contractor and commercial lighting man on account of having the watts per square foot given so clearly." In view of the generally cordial reception to data of this nature, several papers of similar characteristics have since appeared from time to time in the TRANSACTIONS.

Ten years have elapsed since the original material was compiled. New forms of illuminants have appeared on the market, many developments in lighting accessories have taken place, and the art of illumination has advanced. The time seemed logical, therefore, to conduct a similar survey. Over 600 small stores of the class under consideration were visited, and as before, the following facts noted and tabulated: type of store, dimensions, height of ceiling, color of walls and ceiling, number of outlets, type and size of lamp, reflector or globe equipment, type of fixture, arrangement of lamps, height of lamps and general effect of lighting. In the show window similar data were obtained.

Ten years ago such portable photometers as were available, were heavy, cumbersome, rather difficult to set up and it was not deemed expedient to make illumination readings in the stores visited, We now have the foot-candle meter; a compact, little device, self-contained, which can be carried in the overcoat pocket. A mere turn of the rheostat handle makes the device ready for use, and readings can be obtained almost instantly. With its aid, therefore, illumination readings at a number of points were taken in each instance and minimum, maximum and average values were secured.

Before attempting to analyze or compare the results of the two surveys, let us stop a moment to determine from partly theoretical considerations, what the lighting requirements of the class of interior under consideration really are.

There are three separate types of stores; the distinctive shop, the large drygoods and department store, and the typical small store such as found in every community. Due to various factors and economic considerations each of these types has different lighting requirements.

The distinctive shop is handsomely finished, located in an exclusive section of town, and will expend any reasonable amount for lighting in order to obtain some desired effect. In other words, efficiency of light utilization as such is a secondary consideration. The department store with its ramifications obviously presents a different problem. The third class is the neighborhood shop or small store, toward which attention is particularly directed in this paper. Such stores likewise have requirements peculiar to themselves. The capital invested is relatively low and a large expenditure for elaborate fixtures would be injudicious. Surroundings are usually simple, and ornate lighting equipment would be inappropriate. The store is often kept open for a rather long period to make a few low value sales. The profit per individual sale is relatively low and the cost of lighting must be kept at a minimum. In other words, the desired intensity and quality of light must be obtained in an efficient manner.

A luminaire for the small store must fulfill several requirements:

1. It must have a relatively high output to keep the cost of operation as low as possible.

2. It must not expose the bright filament to view, but rather soften or diffuse the light.

3. It must be low in first cost to prevent the investment charges being excessive.

4. It must be neat and simple in appearance. There is little requirement of distinctiveness in this class of service and in general, plain, severe lines are in better taste than ornate decorations.

5. It must not concentrate the light in a narrow angle, but emit considerable flux to the sides to illuminate the wall shelves.

6. It must not tend to accumulate an excessive amount of dirt.

7. It must be easy to clean.

Having analyzed what seemed to be desirable qualities of a luminaire for the small store, let us see what was actually in use

a decade ago, and what is now employed; then let us attempt to assign the reason for such changes in practice which may have occurred.

LAMPS

In 1912 the Mazda B (vacuum, tungsten filament) lamp was practically the standard electric illuminant for the small store. It possessed advantages for this class of service which made its adoption universal, and had then been on the market long enough to supplant the inefficient carbon and gem lamps for general illumination. The most popular size was the 100-watt. The 150-, 60-, and 250-watt sizes were next in order of popularity, but the first mentioned was used in far the greatest number of cases.

The Mazda C (gas-filled, tungsten filament) lamp appeared on the market in 1914. Due to its higher efficiency and improved color value, it rapidly replaced the Mazda B lamp, and as indicative of present practice as to size and type of lamp used in this class of installation, we find, in the 600 stores investigated at the present time that the following percentages hold.

	Per cent
100-watt Mazda C	18.8
150-watt Mazda C	15.8
200-watt Mazda C	58.0
Above 200-watt	3.9
Mazda B lamps	3.5

There has evidently been an appreciable increase in the average wattage per lamp, but as will be pointed out later, this has not necessarily been attended with an increased power consumption.

Multiple unit fixtures have been replaced by single unit luminares, advantage having been taken of the increased efficiency of the higher wattage lamps.

REFLECTOR EQUIPMENT

At the time of the first survey, the clear or bowl frosted Mazda B lamp in the deep bowl, open bottom, prismatic or opal glass, direct lighting reflector was to all intents and purposes, universally used. There were a few flat or shallow reflectors, which exposed the lamp to view, and some enclosing globes in use. The Mazda C lamps were first installed in such reflectors, designed for the vacuum lamps, already in service. In some instances, the reflecting equipment was of such a nature as to be fairly satisfactory, in others, the bright filament was visible or improper distribution of light resulted.

It is well recognized throughout the industry that it is desirable to install equipment specially designed for use with the Mazda C lamp. Gradually the old style reflectors have been replaced and modern types of luminaires installed, as evidenced by the data presented below. The enclosing unit might now well be considered as the standard.

	Per cent
Enclosing and semi-enclosing luminaires	69.8
Totally and semi-indirect luminaires	10.1
Deep bowl, direct lighting luminaires	10.3
Shallow direct lighting luminaires	7.8
Bare lamps	2.0

There is no special tendency indicated as to the use of a certain type of equipment in a given class of store as indicated by Table I.

TABLE I.

Class of store	Number Inspected	Type of equipment			
		Enclosing	Semi-indirect	Bowl reflector	Other forms
Barber shop	30	26	3	1	–
Cigar	20	8	–	12	–
Clothing, etc.	155	107	19	25	5
Confectionery	38	24	5	7	2
Drug	41	25	5	11	–
Florist	19	12	4	1	2
Food products	114	87	7	18	2
Hardware	27	16	1	8	2
Jewelry	14	7	1	6	–
Music	22	16	4	2	–
Restaurant	37	32	2	3	–
Shoe	36	21	7	6	2
Stationery	39	22	6	11	–

The question arises, is this tendency toward the use of a diffusing rather than a directing unit desirable in store lighting, and why were so few used ten years ago? Answering the second question first, we must remember that in the early days of the Mazda B lamp, almost everyone was thinking of the question of efficiency; the aim was to design a device which would direct a maximum amount of the generated light toward a given plane. Lighting men thought of everything in the terms of a certain working plane; a certain area to which the light should be confined. This was to be expected as an outgrowth of the day of the carbon lamp, which emitted comparatively little light to begin with, and it was economically important to use as much of this as possible.

When you take a really rational view of the problem of store lighting, it is apparent that what is required, is a general illumination of the entire superficial area. We need a flux of light in every direction to create the impression of brightness and to make the interior cheerful and attractive. This question seemed to trouble people in those days, when they were constantly thinking in terms of a working plane, for throughout the paper referred to, we find statements as follows: "Art Stores * * * * * the walls on which the pictures are hung form the planes of illumination; bakeries * * * * the counters and pie racks require the illumination; barber shops * * * * the faces of the patrons furnish the plane of illumination; cigar stores * * * * the planes of illumination are the counters and show-cases; delicatessen stores * * * * the shelves and show-cases, which occupy both sidewalls, are the principal planes of illumination, with the counter as a secondary consideration; drygoods * * * * the counter forms the plane of illumination; grocery stores * * * * the shelves and counters here demand an equal amount of the light; restaurants * * * * the tables are the places on which the illumination is desired; shoe stores * * * * the plane of illumination here is about one foot above the floor and there are secondary planes, which are the surfaces of the boxes lining the walls; wine and liquor stores * * * * there is no definite plane of illumination, as the shelves and counter demand equal amounts."

It is quite apparent from the above quotations, that we had the concept of what was desirable and yet could not get away from this idea of the working plane.

The enclosing unit, which has come into widespread use, sends the light more or less uniformly in all directions, and is a logical choice. We have here an excellent illustration of that great, general principle which prevails in the development of any art, which is, in brief, the thing best suited to a given condition will eventually succeed.

Now, of course, there have been other factors which accelerated this tendency. The filament of the Mazda C lamp, due to its concentrated form, is much more brilliant than that of previous types of incandescent lamps, and the necessity for shielding the eye from the filament is greater. With the concentrated

filament, additional means of diffusion must be given consideration, for, without this diffusion, shadows are sharp and harsh.

The enclosing globe shields the eye and introduces the desired diffusion. It is true that the light output is not as great as that of an open bottom direct lighting reflector, but as we have a much more efficient light source, we can well afford to improve the *quality* of illumination and obtain the same *quantity* as before without increasing the cost.

TYPE OF SUPPORT

Ten years ago, stem or multiple arm fixtures prevailed, many being relics of the day of the old chandelier. These have been superseded by the single chain suspension or ceiling fitters, which are used in ninety-two per cent of the installations.

MOUNTING HEIGHT

There is still a tendency, on the part of the uninitiated, to hang luminaires too low, with the belief that better illumination results will be obtained. Those of us who have given the matter serious consideration, realize that this, in general, is not the case, that lamps should always be well above the line of view. Ninety-five per cent of the ceilings in the stores investigated were more than ten feet from the floor, and approximately nine feet is the lowest that it would be desirable to hang the size of unit employed in the average store. With the ceiling heights prevailing, the lamps could well be ten or eleven feet high.

COLOR OF SURROUNDINGS

Eighty-four per cent of the ceilings would be classified as light in color, white, or cream, the remainder, sixteen per cent were finished a medium dark tone. In forty-one per cent of the stores, shelves with merchandise filled the wall spaces, twenty-two per cent had what would be classed as light walls, thirty-four per cent as medium, and three per cent dark in color.

INTENSITY OF ILLUMINATION

In Table II are tabulated the figures obtained in the investigations of 1912 and 1922, the range and average values of watts per square foot employed in both years, and the average foot-candle values prevailing in 1922.

In comparing the average watts per square foot of eighteen classes of stores investigated, we find that comparatively little change has taken place during this interval. Six of the classes

TABLE II.

Classification	1912				1922							
	Watts per sq. foot				Watts per sq. foot				Average foot-candles			Intensity recommended Foot-candles
	No. inspected	Minimum	Maximum	Average	No. inspected	Minimum	Maximum	Average	Minimum *	Maximum*	Average	
Bakery	29	0.3	1.7	0.8	14	0.3	1.3	0.85	2.5	7.5	5.7	6.0
Barber shop	34	0.5	2.6	1.2	30	0.7	2.5	1.5	2.5	10.0	6.5	8.0
Cigar store	29	0.4	2.0	1.5	20	0.8	4.4	1.6	3.5	11.0	7.1	1.00
Clothing	78	0.3	3.1	1.4	37	0.6	2.5	1.2	3.5	9.0	6.0	8.0
Confectionery	30	0.3	2.4	1.0	38	0.5	2.3	1.1	3.0	12.0	5.3	6.0
Delicatessen	29	0.4	3.4	1.1	40	0.5	2.5	1.1	3.0	11.0	5.7	6.0
Drug	24	0.4	1.9	1.0	41	0.3	1.5	1.0	2.0	11.0	6.0	8.0
Dry goods	28	0.7	2.5	1.3	53	0.4	2.6	1.2	3.0	10.0	5.7	8.0
Florist	13	0.5	1.6	1.1	19	0.5	4.0	1.2	2.0	8.0	5.0	6.0
Grocery	53	0.3	2.7	1.0	35	0.2	2.0	1.0	2.0	10.0	5.1	6.0
Haberdashery	23	0.6	5.0	1.4	35	0.7	2.5	1.5	4.5	13.0	7.0	8.0
Jewelry	26	0.5	4.4	1.5	14	0.9	2.2	1.3	3.5	10.0	6.4	8.0
Meat market	32	0.4	2.4	0.9	25	0.5	2.2	0.9	3.0	9.0	5.2	6.0
Millinery	27	0.3	4.2	1.3	32	0.5	3.3	1.3	3.5	10.0	6.6	8.0
Music	11	0.6	1.9	1.1	22	0.5	2.6	1.2	3.0	12.0	5.3	6.0
Restaurant	27	0.4	3.2	1.1	37	0.3	1.8	0.9	2.0	8.0	5.1	6.0
Shoe	31	0.4	1.9	1.0	36	0.6	2.8	1.2	3.5	11.0	5.8	8.0
Stationery	35	0.5	2.4	1.0	39	0.3	1.7	0.9	1.0	8.0	4.3	6.0

* Readings were taken at counter level. The values given as minimum and maximum represent the average of the readings in the poorest and best illuminated stores and not individual stations.

showing the same average, five 0.1 up, one 0.2 up, one 0.3 up, two 0.1 down, three 0.2 down.

These results indicate a tendency which has been recognized for a considerable time, namely as the efficiency of lamps is increased there is practically no change in the specific power consumption for most classes of service. When the Mazda lamp appeared on the market giving three times the light of the carbon lamp, many believed that there would be a remarkable decrease in power consumption. Observations, however, indicated that this did not hold, but that the slogan "Three Times the Light for the Same Money" held true.

In 1912 the efficiency of the lamps ordinarily employed for store lighting averaged about eight and one-half lumens per watt. At the present time they average about fourteen and one-half lumens per watt, hence if the same wattage per square foot is employed, there has been an increase in generated light approximately seventy per cent.

The values obtained of average foot-candles coincide fairly well with the values of watts per square foot and check with computations taking into consideration the dimensions of the room, color of walls and ceiling, type of equipment employed and efficiency of the lamp. It is safe to make the general statement that for the conditions prevailing in the typical small store with the style of luminaire employed in the majority of instances, that an average of five foot-candles will be obtained with each watt per square foot of floor area.

ARRANGEMENT OF OUTLETS

For purposes of simplicity, we may well consider all types of small stores as having similar general lighting requirements. A few exceptions to this are noted in the following section. On this assumption we may divide the small stores into three main groups, depending on their dimensions.

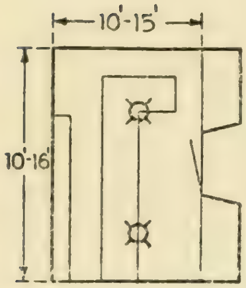
(A) A square room averaging 12 x 12 feet with a possible variation from 6 to 18 feet. This type of store is encountered where the living rooms or work shop of the proprietor are located in the rear, the building being on a standard city lot.

(B) A long narrow store, averaging about 12 feet wide and 40 feet deep. This type of store is produced where the building of standard width is divided into two stores.

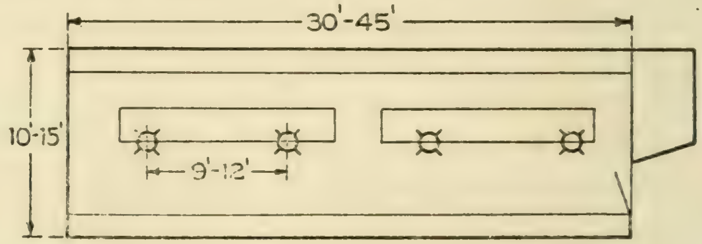
(C) The store occupying an entire lot. Average width 20 feet, length approximately 50 feet.

The six hundred stores investigated fell in these groups in the following proportions:

	Per cent
Type A—small square	7.2
Type B—long narrow	43.7
Type C—full width	49.1



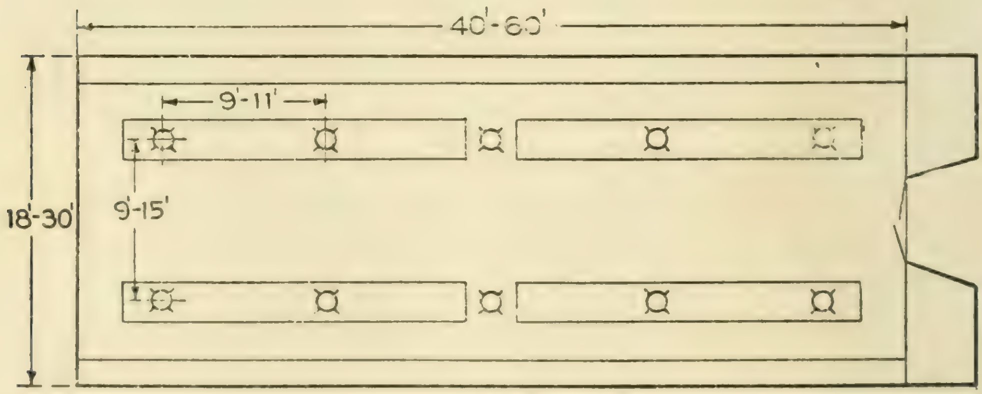
TYPE A



TYPE B

Fig. 1.—Arrangement of outlets for Type A (small square) store. Two 150-watt Mazda C lamps in deep bowl direct lighting reflectors, if the side walls are dark; in opalescent enclosing units, if the side walls are light. If the dimensions are greater than 10 x 15 feet, 200-watt lamps should be provided or four outlets installed.

Fig. 2.—Arrangement of outlets for Type B (long narrow) store. 200-watt clear Mazda C lamps in light density opal enclosing globes hung nine to twelve feet above floor.



TYPE C

Fig. 3.—Arrangement of outlets for Type C (full width) store. 150-watt clear Mazda C lamps in light density, opal enclosing globes hung nine to twelve feet above floor for stores up to twenty feet in width. 200-watt units of the same type for stores from twenty to thirty feet in width.

The typical layouts of such stores are shown in Figures 1, 2 and 3. Considering that the opalescent enclosing unit is to be used, these various groups of small stores are being well lighted according to the following procedure.

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Fig. 4.—A thoroughly up to date barber shop (70 x 15 feet) illuminated by fourteen 100-watt Mazda C lamps in enclosing semi-indirect luminaires. These are placed close to the ten foot ceiling. A uniform intensity of over five foot-candles prevails.

Fig. 5.—Night view of a typical cigar store (15 x 12 feet) illuminated by three 150-watt bowl frosted Mazda C lamps in prismatic glass deep bowl reflectors. Average intensity of illumination is approximately seven foot-candles.

Fig.6.—Night view of a typical drygoods store devoted to women's wear. A neat, yet effective semi-indirect luminaire is used with a 200-watt clear Mazda C lamp. Eight outlets are used in this store which is 70 x 24 feet. A reasonably high intensity of illumination, eight foot-candles, results due to the light finish of all surroundings.

Fig. 7.—A small haberdashery shop (30 x 15 feet) lighted by three 200-watt Mazda C Daylight lamps in enclosing, light directing, luminares. The ten foot-candles of general illumination enables one to make critical selection of the merchandise on display.

(A) Two outlets with units of the 150-watt size for those stores of dimensions up to 10 x 15 feet. Above these dimensions, two 200-watt units or preferably four outlets, with 100- or 150-watt lamps. The relatively high wattage is necessary due to the small dimensions of the shop. Proportionately more of the light is absorbed by the side walls with a resultant lower intensity on the counters for a given wattage.

(B) The long narrow store is satisfactorily illuminated from a single row of outlets. The 200-watt size proves most generally suitable. Spacing can vary between 9 and 11 feet. As the length of the store in general, varies between 30 and 45 feet three or four outlets have become more or less standard practice.

(C) The store of 18 to 30 feet in width is generally provided with two rows of outlets on from 9 to 11 foot centers. The 150-watt size of unit should be used up to widths of 20 feet, above this, the 200-watt size.

SPECIAL FEATURES TO BE OBSERVED

Barber Shops

As the patron is required to lie back in the chair for an appreciable time, bright light sources are particularly objectionable. Although the enclosing type of direct lighting unit works out fairly well in practice and is widely used, a semi-indirect system is preferable, for the brightness of the glassware should be of a low order. This system has additional advantages in the way of diffusion and reduces shadows which would be objectionable when shaving or cutting the hair. The surroundings in the modern shop, Figure 4, are light in color making the conditions favorable for this system.

Convenience outlets should be available at each station to which the various appliances can be attached.

Cigar Store

The typical cigar store is small in size (type A). The surroundings are usually dark and frequently the walls are lined with cases, as in Figure 5, which are of little use in reflecting the light which strikes them. The material on display is dark in color and of a nature that must be examined rather critically. A fairly high intensity of illumination is quite desirable.

The combination of small size and dark surroundings make it generally necessary, as indicated by Table I, to use the open

bottom, direct lighting reflector where costs must be minimized. Where it is desirable to satisfy the most critical customer, a color matching unit of the accurate type can well be provided on the counter for the examination of the shade of cigars.

Clothing and Dry Goods Shops

Mazda daylight lamps can often be used to advantage in assisting the customer in the selection of material. (See Figure 7). The mistake is frequently made of providing too low an intensity of illumination. The more progressive shops provide accurate type artificial daylight units over the triplicate mirrors in the clothing shop and on the counter in the drygoods store and haberdashery for matching goods, selecting neckwear, etc. In the millinery establishment, some decorative form of luminaire over the mirrors at the vanity tables should be given consideration.

Confectionery Stores

These shops are somewhat more elaborately decorated than most small stores and an ornamental or decorative type of luminaire may be more desirable. In many of the shops the rear half is devoted to an ice-cream parlor where special lighting effects may well be introduced. To maintain the desired cool atmosphere, electric fans should be provided and in addition, convenience outlets at the rear of the soda counter are necessary for the agitator or stirrer.

Frequently the candy-making or ice-cream factory adjoins the store. The wiring layout should be such as to enable the proprietor to operate electrically such devices as ice-cream freezer, melting and mixing kettles, marshmallow and cream beaters, mixers, choppers, grinders, cutters and rollers.

Florist Shop

The lighting can be so arranged as to render the store most attractive, as evidenced in Figure 11. A slightly decorative form of fixture can be employed to advantage and in some instances, artificial flowers can be combined with the supporting fixture in an artistic manner. Electric refrigeration will prove a decided convenience.

Food Products

In common, with most stores, there is no one point which demands the highest intensity. An adequate amount of general illumination will create the impression of a cheerful, sanitary shop. (See Figures 8 and 9).

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Fig. 8.—A small delicatessen shop (30 x 20 feet) as it appears by night lighted by three 200-watt clear Mazda C lamps in opalescent enclosing globes. This luminaire, neat and inconspicuous, is in keeping with the character of the shop. An intensity of six and one-half foot-candles prevails on the horizontal plane with slightly less illumination on the shelves.

Fig. 9.—Night view of a progressive grocery store ([illegible] x [illegible] feet) lighted by eight [illegible]-watt and four 150-watt Mazda C lamps in a new and attractive design of opalescent enclosing globe. Although outlets are spaced on [illegible]-foot centers, the illumination is in the order of six foot-candles throughout the store.

Fig. 10.—A modern drug store (40 x 30 feet) as it appears by night, lighted by twelve 200-watt Mazda C lamps in light directing enclosing luminaires. This merchant believes in the drawing power of light, and provides eleven foot-candles of general illumination.

Fig. 11.—Light is a valuable decorative medium in the florist shop. This establishment (50 x 20 feet) is carefully planned, well painted and maintained. It is lighted by seven multiple unit luminaires, each supplying five 40-watt Mazda B lamps in spherical opalescent diffusing globes. The average intensity is in the neighborhood of eight foot-candles. It is a pleasure to shop amid such surroundings.

In most instances, the bake shop adjoins the retail store and the proper illumination of this room must not be overlooked. It has been definitely proven that with proper lighting the output of the industrial plant is increased and sanitation improved. Recognizing the importance of this feature, most cities have ordinances in force relative to the ventilation and lighting of bake shops. The RLM Standard Dome reflector and Bowl Enameled Mazda C lamp or similar efficient equipment, should be installed here, providing eight to twelve foot-candles. In the modern bake shop the automatic or semi-automatic machines are electrically driven and provision must be made for supplying these with power.

In the grocery, delicatessen, meat market, convenience outlets for supplying the small motors on the coffee grinder, meat slicer, stirrer or beater, and meat grinder should be installed. The refrigerator can be operated in a most satisfactory manner by electrical means. Where the ice-box or refrigerator is of appreciable size, it should be furnished with a few low wattage Mazda lamps which are controlled from the outside and so wired that a pilot light indicates when these are burning. Sometimes refrigerating display cases are used to advantage, and of course, should be illuminated in such a way as to minimize the heating effect of the lamp.

Jewelry and Cut Glass Shops

In stores of this nature, direct lighting is generally desirable. Too great an element of diffusion or softness of light is not well suited to make the display appear to the best advantage. The merchandise should sparkle by reflecting the light source. Mazda daylight lamps have been used in many installations with good effect. In wiring jewelry shops, one must not forget to provide convenience outlets for the jeweler's lathe, buffer, and soldering iron.

Shoe Store

The most important point to be illuminated is about one foot from the floor where the shoe is being fitted. A suitable intensity of illumination is also necessary on the faces of the boxes which line the walls. The typical shoe store has a double bench, seats back to back, running its length and two rows of units are

generally advisable. A type of equipment which sends the major portion of the light downward is to be preferred to one which distributes light over a very wide angle.

If a repair department is part of the establishment, an electric motor will be required for driving the shoe machinery. To facilitate speed and accuracy, plenty of light should be supplied from standard industrial units.

Show Windows

In the large store, the art of show window lighting has experienced remarkable advances within the last decade. There are now many windows lighted in color, and spot light effects are to be seen on every hand. The small store can benefit by following some of the practices worked out in the large department store, although in the latter we have quite different conditions. A trained man or group has charge of the display work and devotes considerable thought to the proper arrangement of merchandise. The window is usually "boxed in," whereas in the small store the window is usually open.

In the open windows there is still a tendency to utilize the same type of equipment as used for lighting the store proper, the window lighting being virtually a continuation of the store lighting, in fact, the investigation showed this practice to prevail in thirty per cent of the cases. It is well established that visible lights in the show window are not desirable. Lamps should be equipped with efficient reflectors and concealed from view.

Certain classes of small stores, *i. e.*, cigar, clothing, drug, dry-goods, haberdashery, jewelry, millinery and music usually employ a "boxed in" window and in general, these are fitted with what might be termed standard window lighting equipment. The watts per running foot average 56. There is still much room for improvement and there is no good reason why the merchant with a small establishment cannot make his windows a decided sales asset. Novel lighting effects are not necessarily expensive and will do much toward this end.

In conclusion, the author wishes to express his appreciation of the work done by Messrs M. Horner, H. A. Cook, and E. F. Carrington of the Edison Lamp Works who compiled the data and obtained the photographs used to illustrate the text.

DISCUSSION

The paper by Mr. A. L. Powell was discussed through correspondence.

G. H. Stickney: Prof. Robert Thurston frequently advised his students that, whenever undertaking a new problem, they should first, secure an understanding of "the present state of the art." It was with such a thought in mind that I started Mr. Powell on the investigation reported to the society ten years ago.

In the discussion, one or two men objected to that class of information as being likely to encourage sameness. Others, however, appreciated its importance, which was further emphasized by the wide extent to which the data was copied and used.

Among the unexpected results of the report was the new appreciation of the importance of the neglected small store to the lighting industry, and the value to be derived from field surveys. This new survey is not so spectacular, since the state of the art is better understood, but it introduces a new factor, namely, an indication of the trend of practice, and this has considerable value in gauging the future and guiding installation design.

The influence of the gas-filled lamp is shown in the displacement of the 100-watt lamp by the 200-watt lamp as the most popular size. Nevertheless, this does not mean a doubling of the power consumption which has advanced but very little.

It is encouraging to note that the standard of illumination has been raised about fifty per cent. This has resulted largely from the increased efficiency of the lamps.

Perhaps one of the most significant features is the trend from the open-bottom reflector to the enclosing and indirect types of equipment, which means, of course, better diffusion and reduced glare, and probably better maintained installations, as well as better decoration.

It seems surprising that clothing and drygoods stores fall in the classes in which wattage consumption has not increased. Perhaps this is accounted for by the fact that the stores investigated are of the ordinary rather than the better grade.

There are a number of other interesting comparisons which may be deduced from the data, but I will not take space to discuss

them. In conclusion. I feel that the report indicates that the small store is still a fertile field in which to cultivate more and better lighting.

F. C. TAYLOR: This survey is a valuable addition to a series of papers analyzing lighting installations made and showing the most modern form of lighting for different classes of stores. Some years ago it was necessary for the central station representative to experiment with the different fixtures and lamps in order to determine the best type of illumination for a certain class of work. At the present time it is seldom necessary to put in a trial installation. By reference to such papers as Mr. Powell has presented, it is now possible to find out what is giving satisfaction, not only in one city but in several. In fact, the TRANSACTIONS of the Illuminating Engineering Society, together with the publications of the Lamp Companies, form the best text book that can be obtained on practical illumination. To be of value, this material must be kept up to date. This, Mr. Powell has done by repeating the work originally performed in 1912.

Mr. Powell has emphasized the necessity of shielding the eyes from the filament of the Mazda C lamp. In my opinion this in one of the greatest defects in many otherwise modern installations. More emphasis should be placed upon this one point by those selling illumination. In any open shade, where the lamp may be seen by the customer or employee, bowl enamel lamps should be used and in the case of drop lights, wherever the image of the filament may be reflected from the work back into the eyes of the employee, bowl enamel or glareless lamps should be used. It is now the duty of the lighting salesman to sell this idea to the customer.

E. A. ANDERSON: I note two rather surprising results in Mr. Powell's excellent paper, reporting the illumination survey of a great number of representative small stores.

The foot-candle levels of illumination found appear to be very substantially higher than those reported in previous surveys by others; in fact, the maximum values for each class of stores are practically double the maximum foot-candle recommendations for similar locations which appeared in standard tables of illuminating engineering practice published as late as five years ago.

Even the average foot-candle levels of illumination found by Mr. Powell are fully as great as the maximum suggested by these older tables of recommended levels. Since the quantity of light recommended in these former tables was fairly adequate for examining the goods on sale, it is apparent that some other important factor has influenced the store owners to select a much higher level. Very little actual test data showing the increased attractiveness of higher levels of illumination in stores is available as yet, however, it seems probable that the high levels of illumination which were found to exist in these stores at the present time resulted from the recognition of the importance of this factor and a practical application of it encouraged by competitive considerations.

A striking proof that the small store owner encountered in Mr. Powell's survey was well convinced of the value of high levels of illumination is found in the interesting table which Mr. Powell includes showing the percentages of the different sizes of lamps found in the various stores. Nearly two-thirds of all the stores used the 200-watt size, which is the largest lamp regularly available with a medium screw base. In other words, a large majority of the store owners used the biggest lamp which could be adopted without changing the lighting fixtures. It is reasonable to suppose, therefore, that when more of the large size or mogul sockets are installed there will be many more lamps of the 300-watt size and larger used, and the levels of illumination will be correspondingly increased above the levels shown.

J. L. Stair: A survey of the manner in which our present day stores are lighted indicates that there is a distinct desire on the part of the merchant to obtain good lighting. He seems to appreciate the advertising value of a well lighted store and at the same time desires to contribute as much as possible to the physical comfort of his patrons and sales people.

In reading this paper, I was impressed with four encouraging tendencies which were brought out by his investigation of the lighting of typical small stores. The first of these is given at the top of the fifth page of his paper and indicates a large use of enclosing types of units which tend to hide the lamp from view. The second important tendency is toward the use of diffused lighting rather than illumination of a concentrated type,

this point is elaborated on the sixth page of the paper. A third very important tendency is in the manner of installing lighting units. The general practice of high mounting will keep the lamp out of range of vision to the greatest possible extent. An increase in the amount of light being used for store illumination may be considered as the fourth important tendency in the lighting of this class of interior.

The paper, as stated in the opening paragraphs, is devoted to the small store or shop, and the lighting methods described and illustrated were practically all of the direct type. Frequent use of indirect illumination is made in stores of some of the classes mentioned in the paper such as florist shops, confectionery stores and jewelry stores. The luminous type of indirect lighting fixture or the use of indirect portable lamps or other concealed lighting methods, can be very appropriately employed in stores of the classes mentioned above. In the jewelry store, especially, a combination of direct and indirect lighting is often very effective. The indirect lighting component is employed to illuminate the ceiling and provide a general illumination of low intensity, while the direct lighting component is directed upon the counters and tables.

On the last page of the paper, Mr. Powell devotes some paragraphs to show window lighting. Proper show window lighting, of course, is one of the important features of the store illumination. To this could be added lighting of show cases and wall display cases, refrigerators, etc., the proper illumination of which is almost equal in importance to that of the show window.

E. D. TILLSON: This paper is very interesting to the writer and particularly as it confirms what has been going on in Chicago. At one time, the utility with which I am connected had about 24,000 direct lighting store fixtures on its lines, which were installed and operated on a rental basis. Practically all of these fixtures were equipped with 100- and 150-watt type B lamps. As the type C lamp was put on the market, a large number of customers demanded that these lamps be installed in the same fixtures. With a 200-watt C lamp they were very glaring and sharp indeed; in fact, the illuminating effects were so raw and manifestly injurious that the central station decided to develop a converter whereby these fixtures would be made into enclosing

units. Some attempt was made to apply this converter with enclosing glassware without removing the fixture, but it became soon apparent that this was not the most desirable thing to do. In the first place, the fixtures had a maximum capacity of 200 watts per unit, which under a direct lighting system might be ample, but with the enclosing glassware was either not bright enough or did not give sufficient illumination to satisfy the customer. Furthermore, the fixtures had become dilapidated in a great many cases so that the transformation, even if practicable, was still incongruous.

Shortly afterward the company started a campaign to sell complete new fixtures of the enclosing variety to replace the old style direct fixtures. Within the last few months some 2,500 have been sold on a basis of deferred payments plus a very small installation charge. It has been found that the 300-watt fixture is in by far the greatest demand. Next in popularity is the 200-watt size, while 400- and 500-watt fixtures account for only a few per cent of the total sales. These new fixtures replace the old, unit for unit, as a general thing. Fortunately the wiring rules of the city of Chicago have been recently changed so that on mixed circuits 1,000 watts are now allowed, while in the case of unmixed circuits 2,000 watts are allowed. Formerly 660 watts was the rule, although special permissions were obtained under certain circumstances to use 1,320 watts.

Thus, if this new fixture is not wired in with drop cords or other similar extensions, six 300-watt units can be put on a single circuit if necessary. These new maximum wattages only apply to fixtures with solid stems, porcelain sockets, nitrogen wiring, etc. The fixtures referred to have been particularly designed to fulfill these stipulations so that the greatest advantage can be taken of the old wiring as found in these small stores, and hence sales resistance is minimized.

The writer is in agreement with Mr. Powell when he states that elaborate expensive fixtures are not called for in small stores. On the other hand, we do not think that this statement is any excuse for poor design or workmanship such as is found in a great many low-priced store fixtures. Even the small storekeeper has money enough to buy good equipment. This is evidenced by the high grade labor saving devices found in this class

of establishment; for example cash registers, motor driven coffee grinders, slicing machines, etc. The writer observed many times that the manufacturers of such equipment maintained high standards of excellence and furnished equipment which is highly finished and mechanically perfect. In contradistinction to this, how often do we see enclosing fixtures where the swivel point is practically at the center of gravity of the glassware so that it hangs at a drunken angle, or else the glassware is in a fitter so constructed that it rocks on the two set screws, or else the stem sticks out from the ceiling at a slant, etc. Glassware, suspensions and other details are also very poor in many installations.

For example, the glassware has such deep and complicated patterns that dirt collection is invited or there is a contraction at some part of the glassware which makes it excessively bright or else produces a bad cutoff. At times there are three or four heavy chains used for suspension where a slender stem would be much more sightly and better in every way. Uneven brightness of glassware is also a serious defect. There are cases of two piece glassware units, or their attempted equivalent in a one piece unit, which exhibits excessive bowl-brightness, while the reflector above performs practically no function whatever.

My opinion is that we as engineers should set a high ideal for fixtures of this class, just as we would for installations which are ordinarily considered more important.

D. W. ATWATER: Having participated in a lighting survey of retail stores for my own organization about a year ago, I was naturally very much interested in the results of Mr. Powell's investigation and in reading his excellent paper on this subject. The data presented corresponds so closely with that obtained last year that the investigations must have been conducted in the same general district. Other surveys, as for instance in the middle west, further confirm these data as representing average conditions in the medium to large sized cities.

While it is gratifying to note the tremendous strides that have been made in store lighting during the last ten years there is yet, however, plenty of work for the illuminating engineer particularly in educating both the electrical contractor and the store proprietor. Not only is it important to point out as Mr.

Powell has done, the proper way to secure correct illumination but it is equally important that the merchant should be instructed how to maintain a lighting system after it has been correctly designed and installed. In the investigation we made it was found that the otherwise canny merchant is absolutely ignorant of the importance of systematic maintenance and particularly in regard to the necessity of obtaining lamps of the correct voltage rating.

While three weeks is usually considered the maximum allowable cleaning interval for lighting equipment in retail stores and although some stores find it pays to clean their luminaires as often as once a week, it was found that only thirty-seven per cent of the stores surveyed cleaned their luminaires as often as once every three weeks. Of the remainder, twelve per cent allowed an interval of two months to elapse, ten per cent three months, and eight per cent even longer periods. See Figure 12.

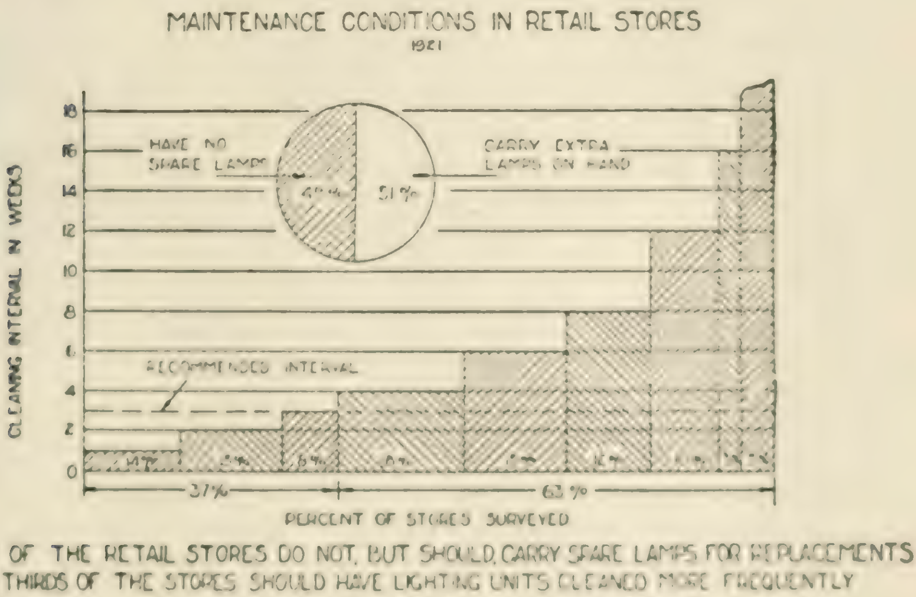

Fig. 12.—Chart showing average cleaning intervals of lighting equipment as found in retail stores.

The responsibility for using lamps of proper voltage rests largely with the electrical dealer and the central station. In one metropolitan city twenty-five per cent of the lamps were rated above the socket voltage and five per cent below, which means that thirty per cent of the lamps were not giving one hundred per cent life and light output, one or the other being considerably reduced.

Another interesting point discovered was that only fifty-one per cent of the retail stores carry spare lamps for replacements. If a lamp is accidently broken or burns out on a busy night it is replaced with a lamp removed from some other socket, or not replaced at all, and the system thus is allowed to deteriorate into a miscellaneous mixture of different sizes and types of light sources.

That there is considerable work yet to be done is shown by the fact that one out of every five store managers interviewed was dissatisfied with his lighting.

J. DANIELS: A few years ago, we made a lighting survey of a number of stores in Boston along somewhat similar lines. The intensities found agreed quite closely with those presented in the paper under discussion. Furthermore, we obtained interesting information as to the status of illumination in the minds of the manager and employees of the different stores surveyed.

From this information, there is no question in my mind that the subject of lighting is considered a very important one. Managers were eager to obtain information concerning the best methods to light their stores and sales people were anxious for the best lighting possible, as they believed it had a great bearing on their sales.

Although this may appear self-evident, we found that the best stores had the best lighting with a tendency toward the use of enclosing units of the dust-proof type.

D. H. TUCK: My mental picture of the average small store or neighborhood shop at night is a dirty window glass and a dirty yellow gleam inside of such low brightness that one must peep inside to find out if the store is open for business or not.

From my observation, I think the small store would do well to discard the opal diffusing type unit as generally undesirable for lighting stores of their type. It must be remembered that lamps are burned until thoroughly blackened and until the filament fails.

The glassware is seldom, if ever, cleaned and the result is the muddy yellow glow characteristic of the opal diffusing globe in the small store.

I would much prefer to use a direct lighting glass unit having a comparatively high brightness, as high as 30 candles per square inch, and of a type which would not give a yellow light when dirty. A prismatic direct lighting enclosing globe is characteristic of the type of unit which is best suited for the small store.

I have seen a great many small stores that have been supplied with very good opal diffusing globes where the globes were afterwards removed so as to get more light in the store.

Brightness, Life, and "Pep" is what the small store needs.

H. T. SPAULDING: The facts obtained by Mr. Powell in his investigation are extremely interesting and of great value not only to those engaged in lighting, but also to the merchant in providing a means of comparing his lighting installations with others having similar requirements. Table II contains much food for thought. By far the most interesting comparison in this table is the average watts per square foot in 1912 and in 1922. It seems surprising that these values should in every case check so closely. It would naturally be expected that in view of the generally increasing lighting standards, the foot-candle intensities found in small stores would have advanced more rapidly than the increase in efficiency of incandescent lamps. The reverse is apparently true. Most of the lighting of this class in 1912 was with open reflectors. At the present time enclosing glassware, semi-indirect and indirect lighting are more prevalent, and consequently, the improved quality of illumination is obtained at a slight sacrifice in intensity. The illumination, therefore, will be less, comparatively, than if similar equipment to that used ten years ago were employed. This, and the fact that the average levels of illumination found are in most cases well below the recommended intensities indicate that there is still work to be done in this field.

WARD HARRISON: The data which Mr. Powell has given us are both interesting and encouraging for they show that the small store owner has not failed to avail himself of the advances in illuminating engineering throughout the past decade. It is particularly fortunate, also, that the surveys at the beginning and

the end of the period were both conducted under the direction of the same engineer. Small stores are a legion and the term of necessity covers the wide range between the poorest corner fruit stand and other stores which approach the classification of "distinctive shops." It would be difficult indeed to insure that the stores surveyed in 1922 were strictly comparable with the stores in 1912 had they been selected by different investigators.

The illumination values, the prevailing lamp sizes, and the types of equipment listed by Mr. Powell are of a somewhat higher standard than the writer would have assumed to apply to shops under the general classification of small stores; in fact, one would incline to the opinion that the stores in the survey are of a somewhat better class than the average for the cities in question or at least for the country taken as a whole. For example, in a survey conducted a year ago in Chicago and reported in the proceedings of the National Electric Light Association for 1921, there were given these statistics for more than 1,000 small stores. A comparison of these figures with those in the present paper indicate that the average level of illumination in the Chicago stores was about twenty-five per cent lower, that is, approximately 4 foot-candles instead of 5.5 foot-candles. At the same time the average watts per square foot in Chicago were about twenty-five per cent higher. These two facts taken together indicate a very much lower order of utilization of light in the stores of the western city and this is substantiated by the fact that twenty-three per cent of the lamps were found to be entirely without reflecting equipment instead of two per cent as in Mr. Powell's survey. Again the great bulk of lighting equipment was in the form of open bowl direct lighting reflectors with perhaps twenty per cent of indirect, enclosing and semi-enclosing luminaires as against eighty per cent of this class of equipment as found by Mr. Powell.

In a less extensive survey conducted in Cleveland in the fall of 1921 the results were found to agree substantially with those reported from Chicago. On the other hand, these apparent differences have no bearing on the main theme of the present paper, that is, the progress in store lighting which has taken place in the

past ten years. And again, there remains the question as to whether or not the stores in the East are more advanced in their lighting practice.

It is interesting to note from Mr. Powell's data that the wattage used to-day in the average store is no higher than in 1912. Since the cost of electrical energy throughout the country has been reduced substantially since that time it means that the average merchant is spending less for light to-day than he did ten years ago.

G. Bertram Regar: Mr Powell's paper is complete and leaves little to discuss. There are several points however which I wish to emphasize, which should be of value to the smaller shops. The single unit enclosing luminaire has done much to improve illumination because it has replaced obsolete low hanging pendants and cluster fixtures, the majority of which were equipped with flat type reflectors with their objectional glare.

The smaller shop keeper especially has not yet realized the psychology of merchandising. A well kept store has both the air of progressism and success. In order to obtain this so-called effect of brightness, the following factors must be stressed: First, the lighting units to be hung high; second, the necessity for light colored wall coverings; third, the importance of efficient maintenance. As a general rule the last two factors are neglected in the majority of cases.

Generally speaking I do not approve of the C-2 lamp for store lighting; it has a cold depressing effect which can be overcome only to a limited degree by using a very high intensity. These lamps have their uses in a number of windows where colored fabrics are displayed and where the intensity is high and the installation properly installed. Very good results can be had by using C lamps and C-2 lamps in alternate sockets.

Colored window lighting has limited possibilities in the small shops because of the nature of construction of the usual windows, the class of patronage and the method of diversified and relatively large display of merchandise. I believe general lighting of high intensity is better. Colored window lighting can be used to splendid advantage during some of the holiday seasons.

There are many merchants, such as oculists, merchant tailors real estate offices, florists, etc., who, owing to the nature of their business, are limited users of window displays and lighting. They can do suggested advertising at a small expense by the use of window spotlights with very artistic effect.

ABSTRACTS

In this section of the TRANSACTIONS there will be used (1) ABSTRACTS of papers of general interest pertaining to the field of illumination appearing in technical journals, (2) ABSTRACTS of papers presented before the Illuminating Engineering Society, and (3) NOTES on research problems now in progress.

REFLECTION FACTORS OF POWDERED PIGMENTS FOR VARIOUS ILLUMINANTS

BY M. LUCKIESH*

The reflection-factor of a colored surface depends upon the illuminant. This fact should be well known but it is often overlooked. Sometime ago the reflection-factors of a group of common pigments were determined for certain illuminants, but these determinations have since been extended to include some of the other Mazda lamps. In making these measurements originally it seemed better to use the dry pigments because they represent something more definite than paints; and, owing to their relatively high purity of color, their reflection-factors will vary over a wider range for a certain group of illuminants than tints of them. In general, tints of these colors will have greater reflection-factors than the pure pigments.

In Table I will be found the absolute reflection-factors for various illuminants including a theoretical illuminant which emits equal amounts of energy of all wave-lenghts throughout the visible spectrum. Two kinds of daylight have been used, namely north blue skylight and noon sunlight. Four Mazda lamps have been used; Mazda daylight, Mazda C at a certain temperature, Mazda B at a certain efficiency, and a "Flametint" or "Golden" Mazda which emits light similar to that of the candle flame. For further comparison Table II is presented in which the *relative* reflection-factors are given as compared with the theoretical illuminants emitting equal amounts of energy throughout the

* Director of Applied Science, Nela Research Laboratories, Nela Park, Cleveland, Ohio

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TABLE I.—ABSOLUTE REFLECTION-FACTORS OF POWDERED PIGMENTS FOR VARIOUS ILLUMINANTS

Classification of pigments	Uniform energy spectrum	Blue sky	Noon sun	Mazda C-2 (daylight)	Mazda C (2780° K.)	Mazda B 7.9 lumens per watt (2375° K.)	Golden Mazda or "flame-tint" (2000° K.)
American vermilion	0.137	0.117	0.137	0.148	0.169	0.177	0.201
Venetian red	0.106	0.095	0.106	0.113	0.125	0.131	0.142
Tuscan red	0.107	0.101	0.107	0.111	0.118	0.120	0.128
Indian red	0.099	0.092	0.099	0.103	0.110	0.112	0.120
Burnt sienna	0.105	0.093	0.106	0.112	0.122	0.127	0.135
Raw sienna	0.324	0.303	0.326	0.340	0.357	0.366	0.380
Golden ochre	0.578	0.548	0.581	0.600	0.623	0.634	0.652
Chrome yellow ochre	0.328	0.289	0.330	0.352	0.387	0.404	0.435
Yellow ochre	0.486	0.460	0.488	0.505	0.525	0.534	0.550
Chrome yellow (medium)	0.542	0.496	0.545	0.577	0.613	0.630	0.660
Chrome yellow (light)	0.760	0.700	0.765	0.788	0.811	0.820	0.839
Chrome green (light)	0.190	0.190	0.194	0.185	0.178	0.175	0.173
Chrome green (medium)	0.136	0.142	0.136	0.132	0.125	0.120	0.116
Cobalt blue	0.166	0.183	0.162	0.152	0.141	0.130	0.129
Ultramarine blue	0.080	0.095	0.074	0.069	0.061	0.057	0.052

TABLE II.—RELATIVE REFLECTION-FACTORS OF POWDERED PIGMENTS FOR VARIOUS ILLUMINENTS

Classification of pigments	Uniform energy spectrum	Blue sky	Noon sun	Mazda C-2 (daylight)	Mazda C (2780° K.)	Mazda B 7.9 lumens per watt (2375° K.)	"Golden" Mazda or "flame-tint" (2000° K.)
American vermilion	1.00	0.86	0.99	1.08	1.23	1.29	1.47
Venetian red	1.00	0.06	1.00	1.07	1.18	1.23	1.34
Tuscan red	1.00	0.95	1.00	1.04	1.10	1.12	1.20
Indian red	1.00	0.93	1.00	1.04	1.11	1.13	1.21
Burnt sienna	1.00	0.89	1.01	1.07	1.16	1.19	1.27
Raw sienna	1.00	0.94	1.01	1.05	1.10	1.13	1.17
Golden ochre	1.00	0.96	1.01	1.04	1.08	1.10	1.13
Chrome yellew ochre	1.00	0.91	1.00	1.07	1.18	1.24	1.32
Yellow ochre	1.00	0.95	1.01	1.04	1.08	1.11	1.13
Chrome yellow (medium)	1.00	0.92	1.01	1.07	1.13	1.16	1.22
Chrome yellow (light)	1.00	0.92	1.01	1.04	1.07	1.08	1.10
Chrome green (light)	1.00	1.03	1.00	0.97	0.94	0.93	0.91
Chrome green (medium)	1.00	1.05	1.00	0.97	0.92	0.88	0.85
Cobalt blue	1.00	1.10	0.98	0.92	0.85	0.79	0.78
Ultramarine blue	1.00	1.19	0.93	0.86	0.76	0.71	0.65

entire visible spectrum. For example, let us take American Vermilion. Its absolute reflection-factor, Table I, is least for blue sky and increases gradually as the illuminant becomes more yellow in color. It increases from about 12 per cent for blue skylight to about 20 per cent for a "Flametint" or "Golden" Mazda lamp. On the other hand a blue, such as a cobalt blue, reflects more blue skylight than it does the yellowish light of some of the artificial illuminants. Its reflection-factor varies from about 18 per cent of blue skylight to about 13 per cent of the light of the Mazda B or the "Flametint" lamp.

The pigments which have been studied are those commonly used and they represent a wide range of colors. As already stated their variation in reflection-factor for a given group of illuminants is greater than that of their tints. In other words the ranges of reflection-factors represented in the Tables may be considered in general to be maximum ranges to be found in practice when these representative pigments are used. Water colors and various dyes often are purer in color than pigments. In such cases the variation of reflection-factor for the same group of illuminants is somewhat greater.

Further discussion and data pertaining to this subject are to be found in "Color and Its Applications" by M. Luckiesh, pages 168, 248 and 298, of the first edition (1915) and in Chapter XVII, page 350 et seq. of the second edition (1921).

REFLECTION FACTORS OF INDUSTRIAL PAINTS AND PIGMENTS*

BY HENRY A. GARDNER**

During February, 1916, the writer presented a paper entitled "The Light-Reflecting Value of White and Colored Paints,"[1] in which were shown the coefficients of reflection of various wall colors compared with white magnesium carbonate (0.88). Quite large size samples of the coated papers used in illustrating the subject had fortunately been kept in reserve. These had remained in a dark place over a period of five years. In May, 1921, they were taken out and the coefficient of reflection of each determined. The results of the original tests made in December, 1915 and those of May, 1921, are presented in Table I. There is also given in the table the coefficient of reflection on the basis of 0.98 for

TABLE I.

READINGS ON PANELS ON TINTED AND SHADED FLAT WALL LITHOPONE PAINTS APPLIED IN 1915 AND AGED IN DARK PLACE UNTIL 1921

Classification of paints	Coefficient of reflection	
	Basis of 0.98 for magnesium carbonate	Basis of 0.98 for magnesium carbonate
	Date of observation	
	December 1915	May, 1921
Light cream	74	69
Light pink	67	63
Light yellow	65	64
Light blue	61	57
Light greenish yellow	60	60
Light buff	58	60
Light green	47	47
Light terra cotta	46	46
Medium terra cotta	44	44
Light greenish blue	40	39
Medium blue	36	31
Warm green	21	20
Medium green	16	15
Red	13	13
Dark blue	13	9
Dark green	12	9

* An abstract of a paper presented before the Philadelphia Section of the Illuminating Engineering Society, November 10, 1921.

** Institute of Paint and Varnish Research, Washington, D. C.

1 Paint researches and their practical applications.

magnesium carbonate as of May, 1921. Reference to the table will show that light yellow, light green, light terra cotta, medium terra cotta and red suffer no loss in reflection value. Light greenish blue, warm green and medium green showed an average loss of only 5 per cent of their original values. Light cream, light pink and light blue suffered a loss in reflection value of only about 6 per cent of their original values. Dark blue and dark green showed an average loss of 30 per cent of their original values. This latter result may be due to air oxidation of the colors to darker shades. Light buff showed an actual increase in reflection value. This result may be due to slight bleaching of the tint.

It would appear from these results that certain colors, through oxidation or otherwise, may become darker and thus lower in reflection value. While other colors remain stationary, some may bleach and thus show higher reflection factors.

In Table II are given some readings on commercial Flat and Gloss Paints as of December, 1915, and May, 1921, based on 0.98 for magnesium carbonate. The panels coated with these paints had been kept in a dark place and consequent yellowing of the liquid binder was indicated. The drop in reflection value is only about 10 per cent in five years. For the gray paints, an actual rise in reflection value is shown, and this is probably due to slight fading of the tints.

TABLE II.

READINGS ON PANELS OF SPECIAL INDUSTRIAL WHITE PAINTS APPLIED IN 1915 AND AGED IN DARK PLACE UNTIL 1921

Classification of paints	Coefficient of reflection	
	Basis of 0.98 for magnesium carbonate	Basis of 0.98 for magnesium carbonate
	Date of Observation	
	December, 1915	May, 1921
Gloss white X	65	58
White enamel XX	73	66
Flat white X	71	64
Flat white XX	67	60
Light gray	49	52
Medium gray	30	36

In Table III are given the reflection factors of a few industrial flat and gloss paints now marketed. It will be noted that some of them run as high as 82 per cent, a figure extremely high in comparison with similar type paints marketed several years ago. This great advance in the production of interior industrial whites of high illuminating value has come as a result of many years of careful study and selection of the pigments and liquids available for the purpose.

In order to apply the pigments to paper panels, a quick drying binder was selected, which was made of nitrocellulose solution in ethyl acetate plasticized with 5 per cent of water white castor oil, and having a total non-volatile content of 10 per cent. Very flat, densely coated, matte surfaces of each pigment were thus obtained, having sufficient binder to prevent powdering.

TABLE III.

READINGS ON PANELS OF MODERN INDUSTRIAL WHITE PAINTS APPLIED IN MAY, 1921. OBSERVATIONS MADE IN MAY, 1921

Classification of paints	Coefficient of reflection Basis of 0.98 for magnesium carbonate
Exterior white oil paint	71
Non-darkening exterior oil paint	78
Gloss mill white X	74
Gloss mill white XX	76
Gloss mill white XXX	82
Flat mill white	78

In a still further series of tests intended to develop the coefficient of reflection of dry white pigments, a series of the same opaque and transparent pigments used in the previous tests were compressed into firm pellets about one inch in diameter and one-half inch thick. The readings on these are given in the sixth column of Table IV.

In conclusion, it would appar that the following information was gained from the above tests:

1. Commercial industrial paints for interiors are now available, of greater reflection capacity than heretofore.

2. In computing the reflection factors of industrial paints, the factor 0.98 should be used for magnesium carbonate (the standard) rather than 0.88.

TABLE IV.

Classification of pigments	REFLECTION FACTORS				
	White paper	Clear glass plates		Black panels	
	Panels coated with pigments applied in nitro cellulose media Pigment—one part Liquid—two parts	Pigments applied in nitro-cellulose media Pigment—one part Liquid—two parts		Pigments applied in flat liquids Pigment—three parts Liquid—two parts	Dry pigments compressed in pellet form
	By weight	By weight		By weight	
		Black background	Backed by white magnesium block		
Titanium pigment	86	85	85	78	91
Lithopone Grade A	83	80	82	81	91
Zinc oxide (French process)	83	80	81	78	91
Antimonious oxide	83				89
White lead Type A	79	69	75	67	
Lithopone Grade B	78			69	89
Zinc oxide (5% lead)	77			77	87
White lead Type B	76			50	90
Barium sulfate	76	26	64	13	88
Silica	72	48	79	19	
Magnesium silicate	69				
Calcium carbonate	68			38	
Calcium sulfate	64				
Aluminum silicate	62				
China clay					84

TABLE V.

Relative brightness of pigments applied in nitro-cellulose media to white paper panels, May, 1921.* Magnesium oxide arbitrarily given value of 100 as standard	
Zinc oxide (French process)	92.5
Titanium pigment	90.2
Zinc oxide (5% lead)	88.3
Lithopone (Grade A)	88.0
Lithopone (Grade B)	84.7
White lead (Type A)	80.7
Antimonious oxide	79.0
White Lead (Type B)	60.5

* Readings (averaged) in above Table V made with Pfund Colorimeter through kindness of Dr. Pfund and Paul Croll.

3. White paints may show a small loss of reflection value after remaining in a dark place for several years, due to yellowing of the oil content. This loss, however, is probably much less than would occur when paints become darkened due to dust adherence, even over a short period of time. For the walls and ceilings of factories a paint is desired that will initially and permanently give the highest degree of reflection. Off-color products or those that show rapid yellowing of the oil content are considered unsatisfactory.

Tinted and colored paints may or may not show a loss in reflection value upon ageing. The result will vary with the type of tinting color used.

4. White opaque pigments vary in reflection value. It would appear that the greatest reflection is obtained from pigments with the greatest opacity.

5. For determining the reflection factors of industrial paints, it is suggested that two coats be applied under standard conditions to black iron surfaces previously coated with a continous coat of flat black primer. For this purpose, the same amount of each paint should be applied, as determined by weight of paint applied.

SOCIETY AFFAIRS

SECTION ACTIVITIES

NEW YORK

Meeting—May 22, 1922.

The New York Section met on May 22, 1922, in the reception room, Pier 54 of the Cunard Steamship Company on the North River. The assembled members and guests were divided into groups and an inspection trip was made through the Steamship Aquitania under the direction of officials of the Cunard Line. Special attention was given to the lighting system of the Aquitania, the turbine generators and various switch boards and panels were inspected.

Owing to the size of the various groups it was not feasible to hold a discussion at the conclusion of the inspection trips. The meeting proved to be a very enjoyable outing in which about 150 members and guests participated, and it ended the Section activities for the present year.

NEW ENGLAND

Meeting—May 26, 1922.

The last meeting of the year for the New England Section was held at the Engineers' Club on Friday evening, May 26, 1922, with an attendance of about thirty-five members and guests. The speaker on this occasion was Mr. A. L. Powell of the Edison Lamp Works of Harrison, N. J., who presented a paper, "A Ten Year Advance in the Illumination of Small Stores." By the use of lantern slides Mr. Powell gave many interesting comparisons between the illumination of small stores in 1912 and 1922. The paper was followed by a very good general discussion.

CHICAGO

Meeting—July, 6, 1922.

A very novel and interesting meeting was held by the Chicago Section on July 6, 1922. Through the co-operation of the General Electric Company and the Public Service Company of Northern Illinois an installation of the new G. E. Highway Lighting units was installed on a section of Dempster Street near the Evanston Golf Club.

Members and guests met at the Evanston Golf Club, where Mr. J. H. Allen of the General Electric Co. gave an interesting talk on the development of street lighting. He explained the construction and characteristics of the new unit, and showed by curves the particularly uniform illumination resulting from its use. Cost figures based on experience in the East were discussed.

After Mr. Allen's talk the party adjourned to the highway and inspected the new system; by driving over the road the various effects due to the general illumination were noted, also the effect of driving with and without a light, and also, with bright and dim headlights. To emphasize the different effect, the party also drove over a road lighted with the old-style flat reflectors.

After the inspection trip an interesting discussion was held at the Golf Club, in which questions of finance, maintenance of the units, and their efficiency were mentioned. About forty members and guests were present.

TORONTO

Meeting—April 17, 1922.

The Toronto Chapter met at the Chemistry and Mining Building of the University of Toronto on April 17, 1922,

with the Ontario Section of the American Society of Mechanical Engineers to hear a paper, "Industrial Lighting" by Mr. Ward Harrison of the National Lamp Works of Cleveland, Ohio. Mr. Harrison covered the subject very thoroughly dwelling particularly on points of interest in the proper installation of units for mill constructed buildings and proper types of fixtures appropriate for the several different classes of manufacturing processes carried on in these buildings. An interesting discussion was held and the attendance at the meeting was about sixty members and guests.

Meeting—May 15, 1922.

The annual meeting of the Toronto Chapter was held on May 15, 1922, at the Chemistry and Mining Building of the University of Toronto. The annual reports of the Secretary-Treasurer were read and adopted. It was noted that the membership of the chapter had been increased to thirty-four, fifteen members were enrolled at the first meeting in the Spring of 1921.

The following officers for the coming year were elected: Chairman, Professor G. R. Anderson; Secretary-Treasurer, M. B. Hastings; Executive Committee consisting of G. R. Anderson, M. B. Hastings, G. G. Cousins, F. T. Groome, J. Scott, and W. H. Woods.

At the conclusion of the business meeting a paper, "Bowling Green and Tennis Court Lighting" was presented by Mr. R. Love of the Canadian General Electric Company. By the use of lantern slides, views of several installations were shown and an interesting discussion was held. About fifteen members and guests attended the meeting.

COUNCIL NOTES

ITEMS OF INTEREST

At the meeting of the Council on June 8, 1922, the following were elected to membership:

Four Members

WALTER A. BATES,
Engineer and Treasurer, Asst. M'g'r.,
Bates Expanded Steel Truss Co.,
208 S. La Salle Street,
Chicago, Illinois.

MANUEL CLAPAROLS,
Electrical Engineer,
The College of Wooster,
Wooster, Ohio.

RAYMOND A. HOPKINS,
Electrical Engineer,
Stone & Webster, Inc.,
147 Milk Street,
Boston, Mass.

DANIEL L. KENSLEA,
Head of Electrical Department,
Mullane Engineering School,
17 Yarmouth Street;
Boston, Mass.

Thirteen Associate Members

D. G. CAMERON,
Illuminating Engineer,
Phoenix Glass Company,
230 Fifth Avenue,
New York, N. Y.

OTIS AMSDEN GAGE,
Technical Representative in Railway and Marine Sales Division,
Corning Glass Works,
Corning, N. Y.

FRANK K. HIRONS,
Sales Engineer,
Pettingell-Anderson Co.,
511 Atlantic Avenue,
Boston, Mass.

J. H. LYNCH,
District Illum. Sales Engineer,
Westinghouse Electric & Mfg. Co.,
10 High Street,
Boston, Mass.

RALPH R. MAGEE,
Lighting Specialist,
Westinghouse Elec. & Mfg. Co.,
165 Broadway,
New York, N. Y.

HARRY A. PIASECKI,
Instructor,
Seneca Vocational School,
Buffalo, N. Y.

LOUIS M. PROBST,
Chandelier Maker,
Bayley and Sons,
105 Vanderveer Street,
Brooklyn, N. Y.

ARTHUR G. SIAS,
Manager,
Municipal Light Department,
Lowell Street,
Reading, Mass.

AUGUSTUS E. SNYDER,
Assistant Commercial Engineer,
Westinghouse Lamp Company,
Bloomfield, N. J.

W. L. STOCKWELL,
District Illum. Sales Engineer,
Westinghouse Electric & Mfg. Co.,
George Cutter Works,
111 W. Washington Street,
Chicago, Ill.

VERNON M. F. TALLMAN,
Power Engineer,
C. H. Tenney and Company,
201 Devonshire Street,
Boston, Mass.

CHARLES WILSON WARD,
Sales Engineer,
Westinghouse Lamp Company,
1900 Union Bank Building,
Pittsburgh, Pa.

CLARA H. ZILLESSEN,
Asst. Advertising Manager,
The Philadelphia Electric Co.,
1,000 Chestnut Street,
Philadelphia, Pa.

The General Secretary reported the following change in membership:

One Associate Member Deceased

WILLIAM McDONALD,
991 Broadway,
New York, N. Y.

COMMITTEE REPORTS

Progress reports were presented by the following: Committee to Prepare a Bulletin of Residence Lighting by Electricity, Committee on Editing and Publication, Committee to Co-operate with Fixture Manufacturers for the Purpose of Preparing a Code of Luminaire Design.

General Convention Committee—Mr. Julius Daniels, Secretary, gave details of plans which are being made for the Convention, including recommendations for members to be appointed on sub-committees.

REPORT OF TELLERS.—The report of the Committee of Tellers was read and accepted with thanks and the General Secretary was instructed to give the names of the newly elected officers to the technical press. The report of the Committee was as follows:

GENERAL OFFICERS

For President
Ward Harrison
For General Secretary
Samuel G. Hibben
For Treasurer
Louis B. Marks
For Vice Presidents
William J. Drisko

Otis L. Johnson
G. Bertram Regar

For Directors
F. R. Barnitz
Clarence L. Law
A. L. Powell

NEW YORK SECTION

For Chairman
A. L. Powell

For Secretary
James E. Buckley

For Managers
R. B. Burton
J. R. Fenniman
A. M. Perry
H. A. Sinclair
George Strahan

NEW ENGLAND SECTION

For Chairman
R. R. Burnham

For Secretary
C. A. Strong

For Managers
Walter V. Batson
Julius Daniels
James A. Toohey
L. T. Troland
J. L. Tudbury

PHILADELPHIA SECTION

For Chairman
Howard Lyon

For Secretary
H. Calvert

For Managers
H. B. Anderson
C. E. Clewell
Merritt C. Huse
J. B. Kelley
W. E. Saunders

CHICAGO SECTION

For Chairman
A. L. Arenberg

For Secretary
F. A. Rogers

For Managers
J. H. Allen
W. T. Blackwell
F. A. DeLay
F. Lee Farmer
J. J. Kirk

CONFIRMATION OF APPOINTMENTS

The appointment of the following committee members were confirmed by the Council.

As Members of Special Committee of Five to Review Cushing Handbook
Clarence L. Law, Chairman
H. V. Bozell
F. C. Caldwell
L. B. Marks
P. S. Millar

As Member of Advisory Committee of State Department of Labor in New York
L. B. Marks

As Members of the General Convention Sub-Committees

Attendance and Local Arrangements
Arthur W. Marion, Chairman
F. W. Bliss
J. W. Cowles
D. McFarlan Moore
M. D. Riley
Frank L. Sample
C. A. Strong
L. R. Wallis

Finance
H. K. Morrison, Chairman
David Crownfield
C. S. Davis
F. A. Gallagher, Jr.
Robert S. Hale

Publicity
Merle Griffeth, Chairman
A. W. Devine
Louis Gibbs
J. B. Grace
Frank K. Hirons
T. J. McManis
Ralph C. Rodgers

James H. Toohey
E. H. Whitney
P. B. Zimmerman

Entertainment

G. W. Bicknell
J. J. Cadigan
John Campbell
J. E. Greene
C. A. B. Halverson
J. E. Livor
James Palsick

COMMUNICATION FROM AMERICAN CONSTRUCTION COUNCIL IN REFERENCE TO ORGANIZATION.—A communication was read from the American Construction Council in which the Society was asked to appoint delegates to attend the Organization meeting to be held in Washington, D. C., June 19-20, 1922. The President appointed Mr. E. C. Crittenden to represent this Society at this meeting.

NEWS ITEMS

I. E. S. Nomenclature and Standards Approved

The I. E. S. Nomenclature and Standards have been officially approved as "American Standard" by the American Engineering Standards Committee These standards are to be designated by the title, "Illuminating Engineering Nomenclature and Photometric Standards."

In submitting this material for approval the I. E. S. Committee on Nomenclature and Standards thought it best to adhere exactly to the International definitions already accepted, in the hope that this course would facilitate the attainment of a still greater degree of international uniformity in nomenclature and practice. The official text of these definitions is in French, and an authoritative English translation has yet to be agreed upon by the British and American delegates to the International Commission on Illumination.

With the exception of the six definitions replaced by the new international definitions as published in the 1921 Report, the standards approved are identical with those given in the 1918 Report as printed in the TRANSACTIONS.

The A. E. S. C. has voted also to approve the recommendation that the I. E. S. be designated sponsor for the subject of Illuminating Engineering Nomenclature and Photometric Standards. A thoroughly representative sectional committee is now being organized to take care of revisions in the present standards and to formulate any desired new standards falling within the scope indicated by the title.

Dr. Kennelly Honored

Announcement was made in June of the conferring of the cross of the Legion of Honor upon Dr. Arthur E. Kennelly, past president of the Illuminating Engineering Society, professor of electrical engineering at Harvard University and the Massachusetts Institute of Technology, who has just finished a successful year as exchange professor to the French Universities.

Caldwell's Booklet on Motor Vehicle Headlighting

An interesting and instructive booklet on the subject of Motor Vehicle Headlighting has been recently written by Professor F. C. Caldwell of Ohio State University. It contains an analysis of the problem of automobile headlighting, recommendations as to the amount of light required for satisfactory headlighting, a review of headlighting regulations now existing in Ohio and a number

of other states, and much useful information on the subject of headlights, headlight lamps, spotlights and lenses.

The booklet was written primarily for those residing in Ohio who are subject to the headlighting regulations of that state. Copies can be obtained upon request from the Engineering Experiment Station of the Ohio State University at Columbus.

At the 38th Annual Convention of the A. I. E. E. held the last week in June at Niagara Falls, Ont., Mr. Ward Harrison, Illuminating Engineer, National Lamp Works of Cleveland presented a paper, "Light without Glare." Mr. S. E. Doane, Chief Engineer, National Lamp Works took part in the Symposium on Education during which he read a paper, "Education."

Mr L. B. Marks, Chairman of the Committe on Lighting Legislation, represented the I. E. S. at the organization meeting of the Advisory Committee on Places of Public Assembly which was held at the New York office of the Industrial Commissioner of the Department of Labor of the State of New York, June 26, 1922. Mr. Richard J. Cullen, Industrial Code Referee, acted as chairman of the advisory committee.

The purpose of the meeting was to draft proposed rules and regulations relating to places of public assembly, in pursuance of Chapter 405 of the Laws of 1922, and to be known as the State Standard Building Code, which will go into effect on October 1, 1922.

Congress has under consideration a bill providing appropriations aggregating $190,000,000 to be available for highway construction in the next three years. In the interest of improving traffic conditions, it is hoped that the advantages of lighting, as well as surfacing of highways, will receive attention in this connection.

PERSONALS

Mr. John W. Lieb, Vice-President of the New York Edison Company, returned in June from a two months' trip in Italy. While in Rome he was made an honorary member of the National Railway Society. In Turin he attended the ceremonies organized by the Associazione Elettrotecnia Italiana in commemoration of the twenty-fifth anniversary of the death of its first president, Galileo Ferraris. On the monument of Ferraris he deposited two bronze wreaths, sent by the N. E. L. A. and the A. I. E. E.

Mr. H. V. Bozell, who has been for the past two years co-editor of the *Electrical Railway Journal* and more recently editor of the new McGraw-Hill publication *Bus Transportation,* has been appointed as editor of the *Electrical World* in executive charge of the paper, of which he has been acting as the managing editor for the past few months.

Professor F. C. Caldwell, Chairman of the Committee on Education, represented Cornell University at the diamond jubilee exercises of Otterbein College at Westerville, Ohio, on June 11-15. This celebration marks the seventy-fifth anniversary of the founding of the college.

Mr. D. H. Braymer, who has served successfully as engineering editor, managing editor and co-editor of the *Electrical World,* is now devoting all of his time to the *Electrical Review* and *Industrial Engineer,* formerly the *Electrical Review,* which was purchased last

winter by the McGraw-Hill Company. He has been made publishing director as well as editorial director of the new paper, with headquarters in Chicago and he assumed his new duties on July first, after discontinuing his official position as editor of the *Electrical World*.

Professor Charles F. Scott of Yale University was re-elected president of the Society for the Promotion of Engineering Education at its recent convention held at the University of Illinois in June.

Dr. M. G. Lloyd, Chief of the Safety Section of the Bureau of Standards, was recently elected as a director of the Eye Sight Conservative Council of America.

Messrs. C. C. Paterson and B. P. Dudding of the Research Laboratory of the General Electric Co., Ltd., of England visited the I. E. S. headquarters, where they attended the joint meeting of the Committee on Nomenclature and Standards and the United States National Committee of the International Commission on Illumination held on July 11, 1922.

Mr. C. C. Paterson, who is the honorary Secretary and honorary Treasurer of the International Commission on Illumination, is spending some time in this country on matters of interest pertaining to illumination and electrical engineering. He attended the recent convention of the A. I. E. E. at Niagara Falls, Ont.

Mr. Clarence L. Law, manager of the Bureau of Illuminating Engineering, New York Edison Company, was elected chairman of the Metropolitan New York Section of the N. E. L. A., succeeding Mr. T. G. Spates of the Queens Company.

Mr. Law has had wide experience in the electrical industry. He has been manager of the Bureau of Illuminating Engineering since 1911, having been identified with The New York Edison Company since 1906 when he began as a special inspector. For many years he was also in charge of the Survey Bureau. Mr. Law holds many offices in organizations associated with the electrical industry. He served two years as Vice-President of the Illuminating Engineering Society and five years as its general secretary besides being one of its newly elected directors. In the N. E. L. A. he was chairman of the Lighting Sales Bureau, chairman of the Industrial Exhibits Committee, member of the National Executive Committee of the Commercial Section, chairman of the Commercial Division of the section, is past vice-chairman of the New York Companies Section, is chairman of the general meetings committee of the Metropolitan New York Section, and a member of the New York Electrical League and the A. I. E. E.

Mr. Law has had a wide experience in civic organizations and in welfare work and has been active relative with work in employee relations. He is a member of the Broadway Association, Architectural League, chairman of the Publicity Committee of the Fifth Avenue Association and chairman of its Below 26th Street Committee, and a director of the New York State Commission of Prevention of Blindness. He is chairman of the board of trustees of the Association of Employees of The New York Edison Company, in which association he has always taken a great interest.

WARD HARRISON

PRESIDENT-ELECT, I. E. S.

1922-1923

Mr. Ward Harrison, the newly elected President of the Illuminating Engineering Society, was born in East Orange, New Jersey, May 16, 1888, and was graduated with honors from Stevens Institute of Technology in 1909. He entered the engineering department of the National Lamp Works of the General Electric Company in the same year, and was appointed Illuminating Engineer of that company in 1914. In this capacity he has been responsible for much pioneer illuminating engineering work, particularly in the development and application of new equipments for use with incandescent lamps. At the present time Mr. Harrison is at the head of the Illuminating Engineering Staff of the engineering department of the National Lamp Works.

Mr. Harrison was among the first to conceive the possibilities of high power gas-filled incandescent lamps for street lighting, and very largely through his experimental demonstration work the city of Chicago was able to adopt the series incandescent lamps as the standard for street lighting, within only a few months of the time that the first gas-filled lamps were produced in a laboratory. Again in Cleveland, the first large city to adopt the high power gas-filled lamps for White Way lighting, he is credited with the design of the ornamental lantern equipment which effectively utilizes the point source characteristics of the new lamps; a type of equipment which is now being more and more generally favored by other cities.

Mr. Harrison has developed a number of new lighting equipments for office, school, and museum lighting, notably among them a semi-indirect luminaire of dust-proof design. He has always had a particularly close interest in the economic possibilities of better industrial lighting and installed in a Cleveland manufacturing plant what was perhaps the first artificial lighting system approaching daylight standards both as to intensity and diffusion. This installation utilized a new diffusing industrial reflector designed by Mr. Harrison, which was possibly the first

WARD HARRISON

PRESIDENT-ELECT I. E. S.

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industrial luminaire intended not only to avoid direct glare but to provide against undue specular reflection and sharp shadows. In addition to his work as an inventor, he has had a very large share in numerous co-operative programs leading toward the standardization of improved lighting equipment, among which was the RLM standardization for industrial lighting.

In addition to papers covering a wide variety of illuminating engineering subjects, which have appeared in the technical press, Mr. Harrison is the author of a text book entitled "Electric Lighting." He has also been a frequent contributor to the TRANSACTIONS of the Illuminating Engineering Society. Typical titles of papers which have appeared under his authorship are: "The Analysis of Performance and Cost Data in Illuminating Engineering," "Some Engineering Features of Office Building Lighting," "Illumination Efficiencies as Determined in an Experimental Room," "A Combination of Refractor and Diffusing Globe for Street Lighting," "Effective Lighting of Factories as judged by Daylight Standards," "Glare Measurements." Mr. Harrison was one of the lecture staff at the 1916 course in Illuminating Engineering Practice conducted jointly by the Illuminating Engineering Society and the University of Pennsylvania.

For some years Mr. Harrison has been a lecturer in the Illuminating Engineering Course at the Case School of Applied Science. Many of the results of his experimental development work on the principles and practice of illumination in his laboratory at Nela Park, first presented in these lectures, have been embodied in reference bulletins on lighting practice issued by the National Lamp Works.

Mr. Harrison has been active in the work of the Lighting Sales Bureau of the National Electric Light Association. As field director for the Educational Exhibits Committee during 1920 and 1921, he carried through the installation of educational exhibitions of lighting principles in many cities, and was very largely responsible for the development of the novel lighting demonstration methods adopted in these exhibitions. For several

years he was Chairman of the Illumination Committee of the American Institute of Iron and Steel Electrical Engineers and it was during this period that the committee conducted a survey of that important industry and developed standard recommendations for the illumination of different departments of iron and steel works. In addition to special important development work on lighting problems involved in the prosecution of the recent war, Mr. Harrison acted as supervising engineer of conservation representing the United States Fuel Administration in the industrial plants of Northeastern Ohio.

Mr. Harrison became a member of the Illuminating Engineering Society in 1910. He was on the Board of Managers of the Pittsburgh Section for a number of years, and lately has been one of the Managers of the Cleveland Chapter. He was a Vice-President of the Society during the years 1913 and 1914, representing the Pittsburgh Section. Prior to the installation of the Cleveland Chapter, he was the Local Representative of the Society at Cleveland. Mr. Harrison has been Chairman of the Committee on Reciprocal Relations with Other Societies for the past several years. Recently as a member of the Committee on Lighting Legislation and Vice-Chairman of a sub-committee, he had a very important part in the preparation of the new industrial lighting code of the Society which has been adopted as the American Standard.

ILLUMINATION INDEX

PREPARED BY THE COMMITTEE ON PROGRESS.

An INDEX OF REFERENCES to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

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Group photographed at Nantasket Point Hotel, July 31, 1907, during the First Annual Convention of the Illuminating Engineering Society.

TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

VOL. XVII SEPTEMBER, 1922 No. 7

In Retrospect

IT IS A long span from the coming convention of the Illuminating Engineering Society to that first convention in Boston fifteen years ago, when the Society was young and the art to which it was devoted was just taking form. A comparison of the papers discussed at that early meeting with those now prepared bears witness both to the essential unity of illuminating engineering practice and to the changes which have forced wide and sometimes far-reaching variation in methods. In 1907 the flame-arc and the tantalum lamp were the new sources in which keen interest was aroused. They were pushing their way forward, threatening to displace the GEM Lamp, then regarded as standard, the enclosed carbon arc, beloved for its long burning properties, and the Nernst lamp, that invaded the western hemisphere just a few years too late. In those days, too, acetylene lighting was a live issue. Bat's wing gas jets were still in favor and the Welsbach mantle in its inverted form was struggling into a position of security.

Not a single topic was discussed at the first convention which would not be fully pertinent now and from which, making due allowance for the change in sources, valuable lessons could not still be learned. On the other hand there is not a paper scheduled for the coming convention which would have taken the earlier one quite unawares. The changes for the past fifteen years have been in material rather than methods. The new incandescent lamps, at first the vacuum tungsten lamp and then its gas-filled brother, have put out of the running many of the popular fixtures

of the society's early days. As the efficiency of the sources has risen, so has the necessity of better diffusion, even at the cost of reduced efficiency, become imperative. At the present moment we are just at the phase of change which requires the abandonment of many of the old popular shades and reflectors in favor of newer forms suiting the brilliancy and dimensions of the new units. For out-of-doors lighting the arc is not yet dead, in spite of the gloomy prognosis of ten years ago, although the incandescent in the larger sizes has steadily pushed its earlier rival to higher powers and greater efficiency.

The art of illuminating engineering is still growing. Every attempt to standardize it so that the wayfaring man, even though he be a fool, could go to his tables and curves and produce results of the highest quality, has dismally failed. The wayfaring man has, to be sure, acquired a little of deftness and commonsense, but he has steadily found, as he will find in the future, that illuminating engineering is an art rather than a science, a fine art if you please, not to be learned by rote like the multiplication table. To-day our sources of light are the cheapest of general necessities and the art no longer has to be based, as at our first convention, on the attainment of superlative efficiency. One almost may say that the engineer with an imagination is free to follow art for art's sake and to combine the useful with the decorative in a way that gives abundant hope of escape from the grim utilitarianism of the beginning of this century of achievement.

LOUIS BELL

REFLECTIONS

Practical Applications of the Principles of School Lighting

THE LIGHTING of many of our school buildings is far below the standards prevailing in commercial and industrial establishments. This is indeed an unfortunate condition. The eye of the young child is in a formative state, and undue strain at such a period will surely react at a later date. Statistics indicate that a high percentage of absences and failures are due to defective eyesight. Conditions which tend to cause such effects should most certainly be remedied. The economics of the situation are apparent to any thinking individual.

The City of Cleveland recognized that in many of the schools there existed marked opportunities for improvement, employing a competent engineer, Prof. H. B. Dates, to investigate the situation. After a survey of the field and study of conditions, he caused to be installed, under typical conditions, many forms of suitable lighting units. These were tested under his direction as to efficiency and effectiveness. A study was made of such factors as are important in school lighting, including brightness, quality, glare, distribution, and the like. As a result of this investigation, specifications were adopted for a standard unit and lay-out for the Cleveland schools.

In a paper to be presented at the annual convention of the Illuminating Engineering Society to be held at the New Ocean House, Swampscott, Mass., from September 25 to 28, Prof. H. B. Dates analyzes conditions as found, describes the Methods of Test, presents comparative figures on the different systems investigated, as well as the specifications finally arrived at. No one interested in school management can afford to miss this paper and the discussion which will follow.

The Cost of Daylight

AT FIRST thought we all believe daylight to be a free gift of Nature. It is, under certain conditions. The study of the economics of building construction, however, indicates that under many conditions it is not as we imagined,—free. Windows are more expensive to build than the same amount of wall space. The

heat radiating through a window is far greater than through the wall. This, of course, has an effect on the coal pile in winter.

In congested areas and large buildings, the expense of erecting and maintaining light courts is considerable in addition to the overhead on the valuable ground acquired for these. Under many conditions, a given area could be lighted to an adequate intensity with artificial illumination continuously at a lower cost than that necessary to provide daylight.

The authors, M. Luckiesh and L. L. Holliday, in the attempt to point out the economics of the situation, have considered a number of typical cases and have indicated the method of procedure when making determinations of this character. Building managers, architects and designing engineers should be interested in listening to the discussion of this paper.

Plotting of Spectrophotometric Data

WITH THE DEVELOPMENT of new types of illuminants and accessories for modifying the light, it is necessary that the investigator analyze the performance of these in many ways. One analysis which has been given more consideration of late than heretofore, due to an increasing appreciation of its effect, is that of color.

A mere visual examination of light tells very little of its composition. The effect of light on colored test samples, does not tell the whole story. For accurate comparison, it is necessary to analyze the light by means of the instrument known as the spectrophotometer.

The spectrophotometer utilizes a prism, or other means of breaking the light up into its component parts. The relative strength, or intensity of these individual parts or rays, is measured, and this data is interpreted.

The science of spectrophotometry is comparatively new, and as seems to be universally the case with a new science, the methods of plotting results, interpreting these and generally applying the data, have been more or less confused. Each investigator is inclined to develop a slightly different system of interpretation. The time has arrived for standardization of practice.

Mr. F. A. Benford analyzes the methods in vogue at the present time and illustrates the various points brought up with practical examples from concrete cases in a convention paper. He first

discusses the limits which should be applied to such tests, taking into consideration the range of vision of the human eye. Next, the boundary which should be assigned to the various spectral colors; then the choice of units for designating the various rays or wave-lengths.

One point of confusion, is the question of plotting energy or light. By light is meant the energy interpreted in respect to the visibility, or in other words, its affect on the visual mechanism—the eye. This is a difficult subject to discuss in non-technical terms, yet Mr. Benford has made his analysis very clear.

In order to compare various tests, it is desirable to have some common ground, or point of equality. Different investigators have used different values—the merits of these are put forth.

Any individual in the lighting business has occasion when he must interpret these data. There is no text book which takes up the question in such a manner that "he who runs may read." This paper is, therefore, of real service to the art of lighting.

The Lighting of Public Eating Places

THERE IS PRACTICALLY no field of lighting which offers as many opportunities for originality and special effects as the restaurant. Proper lighting is a big factor in the comfort with which one dines and should be given primary consideration by the management.

A survey of the field indicates many types of eating places, varying from the commercial or industrial cafeteria to the elaborately decorative cafe such as found on the Great White Way.

It is quite apparent that the demand for lighting in these various classes of buildings are quite varied. The author, Mr. J. L. Stair, has skillfully handled the subject, pointing out that in the first group utility must be given primary consideration, neatness combined with efficiency.

In the more decorative types, however, we find an extremely wide latitude of treatment. The paper is illustrated by a large number of photographs showing those which have proven successful in service from the standpoint of comfort and originality.

This paper can virtually be taken as a text on the class of lighting which it discusses and used as a guide by the designing engineer or solicitor on which to plan future installations.

Influence of Daylight Illumination Intensity on Electric Current Used for Lighting Purposes in the District of Columbia

THE LARGE Central Station has always had a problem which has been slightly difficult and somewhat expensive to solve. Throughout the day it experiences a certain, normal, constant load. With the sudden darkening due to clouds or the approach of a shower a heavy load is at once thrown on the system, causing an entirely unexpected peak. To take care of these emergencies, expensive storage batteries or additional generators are maintained. The investment in this apparatus could be minimized if a means of predicting the action of the weather were available.

Mr. A. Smirnoff has determined as a result of his investigations that there is a point which he calls the "psychological darkness" at which the consumers begin to turn on the lamps at a surprisingly rapid rate. This is at approximately 1,500 foot-candles in the open air. He has kept a record of many different days, typically clear, typically cloudy, variable and the like, and by means of charts shows beyond question of doubt that as the intensity drops below this figure a sudden rise in current consumption takes place. By use of automatic devices located at what might be termed strategic points in the surrounding country it is possible to record the change in intensity of light and thus warn the operators of the expected load.

It is also possible to predict with a fair degree of accuracy the intensity which will prevail at a given place and a given day, hour by hour.

A study of this paper will prove of much value to the plant operator and it marks a big step forward in economics of lighting.

A Survey of Residence Lighting

CASUAL OBSERVATION indicates that a large percentage of the homes throughout the country is inadequately illuminated, and further, that the average householder is unaware of the possibilities of modern lighting. Until recently, however, no exact data has been available indicating the extent of this inadequacy.

Mr. M. Luckiesh, a scientist, who has devoted much thought to the question of residence lighting, some time ago instituted a survey, results of which will be presented at Swampscott, Mass. By means of a questionnaire, he obtained data as to the actual installations in some fifteen hundred middle class homes throughout the country. Such features as the number of rooms, the type of lighting fixture in each room, the material which shades or envelops the light source, the number of sockets, the total wattage to be used, the number of portable lamps, brackets and convenience outlets, were tabulated and analyzed. The results of this survey are then compared with what the author terms "the conservative ideal average middle class home."

The electrical industry, including the jobber and dealer, the fixture, wiring device and lamp manufacturers and central station representatives should be intensely interested in the results of this analysis, which shows that the average wired home to-day may be considered as only "half lighted." They will be interested in noting the character of equipment in service and the general tendencies as indicated by the findings.

Lighting the Moving Picture Studio

WE ARE ALL fascinated by the romance of the movies and eager for a glimpse behind the scenes. The author, Mr. F. S. Mills, having had much practical experience in this line of work is enabled to visualize conditions to us and point out the field of the various illuminants in making the moving picture industry what it is.

The high intensity arc lamp for special effects, the Cooper-Hewitt mercury vapor lamp for general actinic lighting and the high wattage Mazda C lamp fills its individual place.

The uninitiated often wonders how some of the special effects which he sees on the screen are obtained. Mr. Mills has pointed out some of the little tricks used in lighting the studio which give us the effects appealing and fascinating.

Interior and exterior views of the studio in action and night lighting on "location" increase the popular interest of the subject.

Report of the Committee on Progress for 1922

ONE of the most valuable pieces of work done by a Committee of the Illuminating Engineering Society is this report. Its efficient Chairman, Mr. F. E. Cady, and members constantly follow the literature of the art year by year and by abstracting the prominent articles make possible a report which, as its title indicates, shows the developments which have taken place during the past twelve months.

As a matter of record this report should form a part of every library on engineering. It is a subject of comment in the American and foreign press and frequently quoted.

A Direct Reading and Computing Attachment for Sphere Photometers

COMPUTING scales for use in connection with the photometering of vacuum tungsten lamps on life test have been in use for quite a number of years. The increasing use of the integrating sphere has made it desirable to adapt this arrangement to the sphere photometer.

The scientists at the Bureau of Standards have developed a very ingenious mechanical arrangement for this purpose which could be adapted to any photometer with a movable comparison lamp and fixed head or test source.

The paper, by B. S. Willis, describes in detail the construction of the device, illustrates it in service and diagramatically and gives figures on the high degree of accuracy obtained.

Code of Luminaire Design

ANY ART WHICH does not advance is dead. The art of lighting is by no means even dormant. It is desirable however, that such advance which takes place be guided by and have the benefit of, the most recent investigations and best knowledge pertaining thereto.

New types of luminaires or fixtures are constantly appearing on the market. If the public is to be served in the best manner, these luminaires should not violate the well recognized principles of good lighting.

Recognizing this, some time ago the Council appointed a Committee to co-operate with Fixture Manufacturers to function as indicated by its title, and this report is the result of its action.

There are certain fundamental rules which can be set forth as applying to all classes of luminaires. Various reflecting and diffusing media having properties which are well understood and certain devices serve best for particular uses. The Committee's report contains much valuable data along the lines indicated and though only in tentative form, will prove of material service to those responsible for the design of equipment.

Overcoming Daylight Reflections in Show Windows

REFLECTIONS in the plate glass of show windows created by a bright sky or by outside objects sunlighted to a much greater brightness than those within the display, often cause annoyance by very seriously interfering with the visibility of the display and correspondingly reducing the attractiveness and effectiveness of the show window. It was found that the difficulty experienced with these reflections was overcome by lighting the objects in the display to intensities of the order of 1,000 to 2,000 foot-candles. A description is given of a special lighting installation employing high power spotlights to concentrate artificial illumination on the important objects in the display. With a design of this character a practical installation showed that it was possible to obtain the necessary high intensities and do away with the objectionable reflections without an excessive wattage total.

This paper, by Messrs. Harrison and Spaulding, should be of the utmost interest to the progressive merchant who wishes to obtain the maximum return on his investment in show windows. It should prove of value to the central station solicitor in pointing out a way in which he can materially assist the merchant in one of his most serious problems.

The Regular Icosahedron as a Substitute for the Ulbricht Sphere

THE INTEGRATING sphere is a very valuable piece of apparatus as it enables the photometrician to measure the total light out-put of a lamp or luminaire with one reading. Since a greater appreciation is being given to the relative efficiencies of different lighting devices, the demands for readings of this character are becoming greater and more integrating devices will be used in the future.

The sphere is a rather costly piece of apparatus to construct, particularly in the larger sizes necessary for testing the high-powered light sources. Many attempts have been made to modify the character of the enclosing box to simplify the construction and reduce the cost. The icosahedron offers certain possibilities from the theoretical standpoint.

The authors, K. S. Weaver and B. E. Shackelford, accordingly made a model on a reduced scale and conducted rather extensive tests with various lighting units also in the proper proportion. The details of these tests are presented. As a result of the high degree of accuracy indicated by the preliminary investigations, a full size unit, of a 10-foot height was constructed and placed in service. The details of this are of interest to those engaged in laboratory and testing work.

Lighting Statistics of Representative Urban and Suburban Homes

THE LIGHTING industry is particularly fortunate in being able to obtain the data presented in this paper, by Mr. Norman D. Macdonald. For some time the Association of Edison Companies have been conducting a survey, as indicated by the title. The object of this was to improve service conditions in the residential field. With the resources of these large companies to draw upon, a most comprehensive survey was possible. A field force of many individuals actually visited typical homes and obtained information regarding the various elements of their lighting system. The summation of this data is presented.

Factors which should serve as guides in merchandising equipment or supplying service are now definitely known which heretofore were only roughly estimated. Among these are, the average number of sockets installed, the percentage of these actually in service, the percentage deemed superfluous, the percentage out of commission, the percentage in inaccessible positions, etc., the number of baseboard or convenience outlets in the average home, the type of lighting fixtures employed in the various rooms, the frequency of cleaning, the average wattage per lamp and the like. So many factors are presented that it is impossible to attempt to enumerate all of these in a brief synopsis. One should hear or read the paper to gather the full import of these data.

Lighthouse and Light Vessels, Their Features of Illumination

THE MARINER'S beacons are always a fascinating subject of observation and study. Comparatively little information in regard to their internal structure has been available until now. The author of this paper, Mr. S. G. Hibben, has made an extended investigation of the subject from the physical and practical aspects. He presents data on the relative visibility under varying conditions and analyses these results from theoretical considerations illustrated by easily understood diagrams.

After a brief review of the history, the structure of modern types of lamps is discussed and illustrated by excellent diagrams and photographs. The specialized requirements of the various classes of service are analyzed and the application of the various illuminants for these are pointed out.

The text is written in an appealing style and one is much impressed by the ingenious means which have been used and are now in service for providing a safe passage to ships as they approach hidden dangers.

A Distribution Photometer of a New Design

THERE ARE many designs of distribution photometers in service in the various industrial, commercial, educational and research laboratories throughout the country. It might safely be said that no two of these are exactly alike—each is modified to meet certain conditions, and those of recent construction have avoided the faults experienced with the earlier types, adding refinements and improving the details.

The investigators, Messrs. Colby and Doolittle, who present this paper, before building the device which is described therein, made a careful study of the types in service and chose those elements which had special advantages for their particular conditions. The completed apparatus, which is described and illustrated in detail, has many new features and marks a step of advance in the art of photometry. Records of this character are valuable in guiding practice.

Flicker Photometry

THE SUBJECT of the photometry of colored light is not yet fully understood. Each year new investigators bring forth additional data leading to a clearer conception of the intricacies of the problem.

There are two principal means of comparing light intensities, one known as the "equality of brightness" method, and the other as the "flicker" method.

Discrepancies have always been known to exist between the results obtained from these two methods. In the first half of this paper, the investigators, C. E. Ferree and Gertrude Rand, point out the causes for these discrepancies. They show that difficulties are encountered with the flicker method, because the intensity of the sensation (in the eye) does not vary directly with the intensity of the light, but is dependent upon the time this light has to act on the eye and also on the color. They have found that the flicker and equality of brightness methods agree if the eye is exposed the same length of time with both methods.

They further show that with the time of exposure ordinarily employed in flicker photometry, the eye does not reach the condition of maximum sensation, or in other words, get the full effect of the light, which, of course, obtains when the equality of brightness method is used, for there a prolonged exposure or sighting of the photometric field takes place.

In the second half of the paper, which is entitled "Comparative Studies of Equality of Brightness and Flicker Photometry, with Special Reference to the Lag of Visual Sensation" the authors first describe the ingenious apparatus with which they made these tests.

Figures and curves from the data seem to justify the conclusions mentioned above. They indicate that for various wavelengths or colors, there is a rise of sensation to a maximum value which is different for each color and for each intensity. In other words, it will take a longer or shorter time for the eye to receive its maximum sensation from a given color at a given intensity, in comparison with the time for the eye to reach its maximum sensation from the same color at a different intensity or from a different color at either of these intensities.

Measurement of the Electrical Response of the Retina to Stimulation by Light

SOME TIME ago considerable publicity was given in the daily papers to the experiments performed by the authors, E. L. Chaffee and W. T. Bovie, on the subject indicated by the title. It was found that as light inpinged on the sensitive portion of the eye, changes in electrical resistance or other characteristics was brought about which could be noted by the use of the proper instruments. The eyes of frogs were used for these experiments and the minute changes in current which occurred were amplified by the now widely used radio tube and indicated by a sensitive galvanometer. Some most interesting effects due to the action of light, were discovered through these means.

Lighting the Food Industries

OUR FOOD should unquestionably be prepared under the most ideal conditions for the health and comfort of a country is dependent on its food. Federal and State laws have done much to raise the standard of sanitation in those plants devoted to the preparation of food and in general, conditions are quite satisfactory.

The investigation reported in this paper indicates that one element of plant management has been somewhat overlooked. Lighting men have known for a long while that proper illumination is a very important factor of sanitation. A well lighted shop is perforce clean, for there are no dark corners or shadows in which refuse is allowed to accumulate. Proper lighting also assists in increasing production, maintaining a high morale among the employees and promoting safety.

This paper by Mr. W. H. Radmacher presents data on lighting conditions in a considerable number of factories allied to the food industry. It may, in general, be said that the standards are far too low. Inadequate lighting exists in a high percentage of the plants. A few notable exceptions where the benefits of proper lighting have been appreciated are illustrated and discussed.

The following scheme of treatment is used in discussing the lighting requirements of the various industries. General character of building, analysis of the processes of manufacture, present

lighting practice, recommended practice as to intensity, type of equipment, and method of lighting, and special or peculiar lighting requirements.

The industry is divided into the following headings, each of which is discussed individually. Grain elevators, flour mills, bakeries, breakfast foods, canning, meat packing, ice cream manufacturing, chocolate and candy manufacture, fruit packing and milk testing.

As practically every community has some establishment devoted to the handling or preparation of food products, the data contained in this contribution should be of universal application and valuable.

Skylight Illumination on Horizontal and on Vertical Surfaces

THIS REPORT of the Committee summarizes sky brightness and daylight illumination measurements made during the year ending April 6, 1922. For ten months the measurements were made in a suburb of Washington that is comparatively free from city smoke. During the other two months, one in summer and one in winter, the measurements were made in the smoky atmosphere of the city of Chicago.

The measurements were made as nearly as possible with the sun at altitudes above the horizon of 0°, 20°, 40°, 60°, and 70°; and from the sky brightness measurements the resulting illumination on vertical surfaces differently oriented with respect to the sun has been computed. These computations, in connection with the daylight illumination measurements, have been utilized to construct charts showing for latitude 42° North, the skylight illumination for each hour of each day throughout the year as follows:

(1) On a vertical surface with a cloudy sky, (2) On a horizontal surface with a cloudy sky, (3) Eight charts showing the illumination with a clear sky on vertical surfaces facing N, NE, E, SE, S, SW, W and NW respectively.

The extreme daily deviations from seasonal averages, and the average decrease in illumination intensities at Chicago due to smoke, are also given.

PAPERS

REPORT OF THE COMMITTEE ON PROGRESS FOR 1922*

"The light which we have gained was given us, not to be ever staring on, but by it to discover onward things."—Milton.

INTRODUCTION

While again there does not appear to have been much in the way of development in illuminants since the last report, there has been a great deal of activity in the various phases of applied lighting, and in the study of luminous phenomena. References in various parts of the report show the wide application which is being made of the low candlepower neon vapor glow lamp, which apparently has many possibilities. In fact the number of practical uses which have been found for this lamp is rather surprising. The steady increase in the use of automobiles is forcing attention to street and highway lighting and while the larger cities have not shown any unusual progress, much is reported from smaller cities, towns and counties.

Appreciation of the value of the work of this society is seen in the references to its various codes which occur in almost all reports of British legal committees, in some from Germany, and in the recommendations for state legislation in this country both for industrial lighting and for automobile headlights. The English and German illuminating engineering societies have reported regular meetings but nothing has reached the committee as to what is being done by the Japanese society.

A traveler in Siam[1] has noted that the natives burn holes in the trunks of mai yang trees to collect a resin which they use in lamps. Nearly every mai yang tree is thus mutilated.

It is reported that[2] Sir Humphrey Davy, who was one of the greatest chemists of his time, made the mistake in judgment of objecting to the use of coal gas for the illumination of the City of London partly on the assumption that such a project

* A report to be presented at the Annual Convention of the Illuminating Engineering Society, Swampscott, Mass., Sept. 25-28, 1922.

[1] *Natl. Geog. Mag.*, Mar., 1922, p. 259.

[2] *Science*, Nov. 4, 1921, p. 419.

would require a gas holder as big as St. Paul's Church dome. and it would blow up at the first opportunity.

The Parish Church of St. John the Evangelist, Westminster, London, England, is claimed[3] to be the first church to be lighted by gas. Acum writing in 1816 said that the building had been illuminated by gas lighting for upward of two years, the light employed being "equal to 360 tallow candles, eight to the pound." Nothing is said of the design of the fittings and types of burners.

Many interesting facts regarding the early history of electric lighting were brought out[4] at the Semi-centennial Jubilee meeting of the British Inst. of Elec. Eng. A number of the speakers had vivid recollections of the days when the incandescent lamp was a novelty and the arc lamp none too well established. It seems strange to think that the great city of London was at one time so uncertain as to the best way to do its street lighting that it used three systems; the British system with 16 arc lamps to a dynamo, the Maxim system of a similar character, and the Siemens installation consisting of a number of masts carrying very big lamps each fed by its own dynamo.

Passenger trains operating between London, England, and Brighton, a distance of 52 miles were first equipped[5] with electric light apparatus in 1881 and this is believed to be the first attempt to light a train by electricity.

It is to be regretted that, as in the case of street lighting mentioned in last year's report, so little data on candlepower values are given in accounts of exterior illumination and the committee again recommend to the Society that this subject be considered by the proper committee with the view of preparing suitable forms which shall show all the quantities which it is necessary for a reader to know in order to obtain from a description an adequate idea of the lighting conditions.

Thanks are extended to those who have contributed information and to the publishers of the various journals freely quoted.

Respectfully submitted,

Francis E. Cady, *Chairman*
Geo. S. Crampton,
F. R. Mistersky,
W. E. Saunders.

[3] *Ill. Eng.*, Nov., 1921, p. 221.
[4] *Jour. of Inst. of Elec. Eng.*, Apr., 1922, p. 401.
[5] *Rlwy. Elec. Eng.*, Dec., 1921, p. 473.

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GAS

In describing some interesting facts in connection with the early history of gas lighting it was brought out[6] that in London in 1860 houses piped for gas would have connections from three companies' mains in their cellars. Various methods were used to ascertain which main supplied the lights in the house. One method was to smell the gas as each company's brand had its own special odor. Another method was to drill a hole in each main, insert a ferrule with a flexible tube and force in air. When the air and pulsation extended to the lights the right main was identified.

At the last convention of the American Gas Association data was presented[7] showing that approximately 20 per cent of the gas sold by companies in this country is used for lighting purposes.

Manufacture.—A manufactured gas has been reported[8] in England which with a calorific value of 350 B. t. u. is claimed to give the ordinary consumer the same value as he can get from a 500 B. t. u. straight coal gas. It is used in burners without Bunsen tubes and is supposed to obtain aeration for combustion purposes from the air surrounding the flame. The consumer turns the gas on full by means of the tap at the burner and regulates it until he gets the maximum light with the minimum consumption of gas. No lighting back or breakage of mantles occurs. The gas can also be turned down when required without lighting back.

[6] *Gas Jour.*, Apr. 5, 1922, p. 50.
[7] *Gas Jour.*, Dec. 21, 1921, p. 820.
[8] *Gas Jour.*, Oct. 5, 1921, p. 20.

Additional information is available[9] on the production of gas from straw referred to in the 1918 Progress Report. A test on a machine handling 150 pounds of baled straw gave 850 cubic feet of gas for this amount in thirty-three minutes. Sunflowers will produce 15,000 cubic feet per ton, 10 gallons of light oil, 10 gallons of tar and 640 pounds of carbon. An analysis of straw gas has shown CO_2—30.6 per cent, acetylene—6.4 per cent, CO—28.2 per cent, methane—21.3 per cent, H—11.3 per cent, N—3.2 per cent yielding a calorific value of 469 B. t. u. per cubic foot.

In 1918 the last year for which figures are available[10] the production of monazite sand in India amounted to 2,117 tons a great advance over the last pre-war year's production of 1,235 tons. The outlook is very favorable and it is said the reserves are far greater than those of Brazil or the United States.

Burners.—To supply the need for incandescent units of small size and low gas consumption a new design[11] utilizes the inverted type of mantle on an upright burner. The result is greater rigidity and strength than is obtained with the upright form of mantle and constancy in efficiency owing to the maintenance of the mantle in a central position over the flame. With gas of, say, 475 B. t. u. the consumption is not more than 1.9 cubic feet, per hour at a pressure of twenty-five tenths. Burner makers after many attempts have succeeded[12] in producing suitable burners for gas of as low as 380 calorific value.

German mantle manufacturers as a result of being cut off from the usual foreign sources were reduced during the war to the use of paper thread as a substitute for ramie, and artificial silk.[13] The candlepower of such pure paper mantles was only 60-70 per cent of that from those made of ramie. The woven asbestos reinforcement in the head of upright mantles was replaced by crepe paper and iron wire was used for sewing the mantle tops. Good durability resulted as the flame tops were low and the heat value of the gas was reduced owing to the coal scarcity. In the inverted type a ceramic enamel attached the mantle to the magnesia ring. Condensed phenols were used largely as sub-

[9] *Gas Jour.*, Feb. 15, 1922, p. 379.
[10] *Gas Jour.*, Nov. 30, 1921, p. 617.
[11] *Gas Jour.*, Dec. 21, 1921, p. 810.
[12] *Gas Jour.*, Apr. 12, 1922, p. 25.
[13] *E. T. Z.*, 1921, p. 656.

stitutes for camphor and castor oil in the preparation of mantle collodians.

More recent developments, in Germany,[14] have been made in the direction of making mantles to fit the various kinds of gas now being manufactured. The almost general addition of high percentages of water gas has resulted in lower calorific values and higher flame temperatures. With smaller flames,—due to the alteration in air consumption and flame velocity—the older mantles no longer fitted the flames. Tests on the new product indicated for the upright type a saving of gas of between 19 and 24 per cent with a slight advantage in candles per cubic foot. With inverted mantles the gas saving was between 21 and 23 per cent and the improvement in candles per cubic foot was between 17 and 22½ per cent.

Calorific Standards.—The Bureau of Standards has issued[15] the fourth edition of *Circular* 32 "Standards for Gas Service." The suggested rules in this circular have been followed very closely in the regulations established during the past year by North Dakota, North Carolina, and Maine and in the revised rules of Montana. Very good progress is being made on the Gas Safety Code on which the Bureau and the American Gas Association are joint sponsors under the A. E. S. C. At the Annual Meeting of the Southern Gas Association of the United States[16] a committee resolution declared "that freedom from restrictive standards of gas quality are absolutely indispensable to the relief of the industry and of the public as well." The Committee recommended a range of calorific values from 425 to 525 B. t. u.

In a resumé of legislative action on calorific standards a list is given of those states which have adopted defining B. t. u. values.[17] In seventeen states Commissions have not adopted standards, while in eight states the Commissions have no jurisdiction over gas utilities. The values adopted range from 470 to 800, the latter value being for natural gas. Averages of many years' collections of calorific values, observed and calculated, have been used[18] to make the following table of multipliers

[14] *Gas Jour.*, Feb. 8, 1922, p. 315.
[15] *Gas Age Rec.*, Feb. 25, 1922, p. 239.
[16] *Gas Jour.*, Apr. 12, 1922, p. 100.
[17] *Gas Age Rec.*, Dec. 24, 1921, p. 851.
[18] *Gas Jour.*, Feb. 15, 1922, p. 386.

which gives the B. t. u. content corresponding to the different constituents in gas.

CO	per cent x 3.23
C_nH_m	per cent x 23.29
CH_4	per cent x 10.05
H_2	per cent x 3.20

The next table[19] shows the cubic feet per therm for gas of varying B. t. u. content.

B. t. u. per cu. ft.	Cu. ft. per therm
500	200
490	204
480	208
470	212
460	217
450	222

Up to an including February 28, 1922, calorific values as declared[20] under the British Gas Regulation Act are shown in the following table.

Calorific value declared	Number of declarations
425	6
450	66
460	22
470	20
475	17
480	18
500	29

Other values ranging from 400 to 550 had only two or one declarations. The result of two years' operation under the Act shows an average[21] of 466 B. t. u. for 1920 and 461 for 1921. The slight drop is attributed to the effect of the prolonged coal strike. In view of the general tendency to lower calorific standards it is rather interesting to note[22] a recent movement in England in the opposite direction where a number of companies taking advantage of their liberty in this respect have increased their declared standards. This action is attributed to various causes, notably better coal, and cheaper and more available oil.

[19] *Gas Jour.*, Feb. 22, 1922, p. 448.
[20] *Gas Jour.*, Mar. 29, 1922, p. 759.
[21] *Gas Jour.*, Feb. 22, 1922, p. 452.
[22] *Gas Jour.*, Apr. 5, 1922, p. 19.

Observation and a study of the results of governmental regulation of English calorific standards has led[23] to the following conclusions: economic conditions have determined English standards; in appliances less easily adjustable than those in the United States, 450 B. t. u. and even lower values are being satisfactorily and efficiently used; freedom from restriction as to calorific values has led to the maintenance of the most economic figure for each particular works and has led to the development of new methods and processes; whether or not the "therm" method of charging will prove successful is still an open question but it is better adapted to English conditions than to those in this country.

Statistics covering the use of acetylene[24] for lighting purposes show some 285,000 homes lighted by this gas. In 1920 there were approximately two and one-half million acetylene cylinders in use and about one million miner's lamps in actual service.

The disadvantage of the ordinary candle is its relatively short life. What is probably the largest candle ever constructed, designed[25] for a church in Naples is 5 feet in circumference, 18 feet high and weighs approximately 1,000 pounds. It is expected to have a life of 120,000 hours. This might be contrasted with the life of the ordinary gas mantle of about 1,000 hours.

Auxiliaries.—A novel igniter for gas has been brought out in Germany.[26] It works on the electrostatic principle and consists of four principle parts: the metal casing, the electrophor cover, the electrophor plate, and the ignition chamber. The second part is covered with leather and the plate with rubber. By pushing in the handle the cover and plate are brought close together and a twisting motion causes friction in the ignition chamber which produces a spark where the parts are separated. Another igniter[27] consists of a specially made condenser one element of which is connected by a single wire to the electrical supply circuit and is controlled by an ordinary switch. The other element is con-

[23] *Am. Gas Jour.*, Nov. 19, 1921, p. 461.
[24] *Acetylene Jour.*, Oct., 1921, p. 201.
[25] *Sci. Am. Wkly*, Sept. 17, 1921, p. 195.
[26] *Am. Gas Jour.*, Jan. 7, 1922, p. 13.
[27] *Elec.*, Jan. 6, 1922, p. 16.

nected to a metal brush at the striking end of the lighter. When the latter is charged it emits a series of sparks which are sufficient to ignite the gas.

The Committee of the American Gas Association in charge of standardizing gas tubing[28] has recommended that such tubing, used for connecting gas appliances, must be in lengths of 6 feet, "leakage" being defined as not exceeding 0.02 cubic feet per hour per length. Six tests are detailed and six requirements defined: strength, flexibility, resistance to freezing, resistance to heat, elasticity of rubber slip ends, and gripping power of rubber ends. Several strength tests are listed such as a steady lengthwise pull of 50 pounds for five minutes without leakage; to withstand without leakage or becoming detached the shock occurring when a 5 pound weight attached to one end drops 30 inches, the other end being supported by the rubber slip end attached to a standard hose nozzle held in a vertical position.

INCANDESCENT LAMPS

The incandescent electric lamp seems to have reached the period in its development where striking changes are rare. Whether this is due to insufficient scientific research or to the natural limitations of available materials is a question. Economic conditions have undoubtedly necessitated considerable financial conservatism which has been evidenced in the reduction of appropriations for research, but it is perfectly possible that increased experimental work might not have produced any radical innovation in lamps as at present constructed. However, it is encouraging to note that research work is still going on and that its value and necessity is appreciated to the extent of its adequate maintenance on the part, at least, of a number of the larger concerns in the industry.

Manufacture.—The output of carbon incandescent lamps continues to decrease,[29] the demand for the year 1921 being only 3.6 per cent of the total lamp sales as against 4.3 per cent of the previous year. The distribution of tungsten lamps according to size and types shows 79.4 per cent for vacuum lamps and 20.6 per cent for gas-filled. The average lumens per watt shows an increase from 10.6 to 11.

[28] *Gas Jour.*, Dec. 14, 1921, p. 746.
[29] Report of Lamp Committee N. E. L. A., May, 1922.

The distribution according to voltage indicates a falling off in the 220-250 volt class. In foreign countries the percentage of higher voltage lamps used is materially greater than in this country and in some instances the demand is more than the demand for the 110- and 120-volt class reaching in England almost 80 per cent of the total output. Considerable progress is reported in the reduction in this country to the three standardized voltages of 110, 115, and 120. During the past two year period, of 2,880 central stations furnishing data, the percentage using standard voltages has increased from 76 to 92.5. Of all lamps produced in 1921, 87.2 per cent fell within the standard range of 110, 115 and 120 volts as compared with 81.2 per cent of the previous year.

According to a report of the Lamp Committee of the Canadian Electric Association[30] the 40-watt vacuum tungsten lamp is most popular in Canada and is followed by the 25- and 60-watt. In the United States[31] the 40-watt is in greatest demand followed by the 50- and 60-watt. It is reported that Finland uses approximately two million lamps annually and a factory with a capacity of 300 to 400 lamps per day has been started to restore worn out lamps.

In order to avoid the difficulties in making tight seals in the high wattage lamps used for projection purposes a foreign inventor has returned[33] to the use of a rubber stopper held in place at the neck of the bulb by a metal collar. This procedure was tried out and discarded in this country some years ago.

The black deposit which collects on the interior of tungsten lamp bulbs when the vacuum is of the order of a few thousandths of a millimeter has been ascribed either to the direct sublimation of the tungsten, or to the decomposition of water vapor by the hot tungsten and the reduction by the hydrogen of the oxide formed. As a result of experimentation it is suggested[34] that a further factor in the deposit is the sputtering caused by the expulsion of occluded gas. When wires are prepared with thoria.

[30] *Elec. Wld.*, June 17, 1922, p. 1,245.

[31] Report of Lamp Committee N. E. L. A., May 19, 1922.

[32] *Elec. Rev.* (*L.*), Apr. 21, 1922, p. 571.

[33] *Rev. Gen. d'Elec.*, May 13, 1922, p. 722.

[34] *Phys. Zeit.*, Mar. 15, 1922, p. 136.

gas collects in the interstices and in the cement and is driven out, particularly on rapid heating, with almost explosive energy. It has been found that the particles on the interior of the bulb do not show crystalline regularity as they should if condensed from vapor, but are irregular fragments.

New solutions[35] for the superficial coloring of incandescent lamp bulbs are claimed to give results which do not deteriorate with heat nor suffer from immersion in hot or cold water or from scrubbing to remove dirt.

Types.—New Mill-type lamps in tipless bulbs were listed[36] last Fall. They are made in 25 and 50-watt sizes for 115 volts and in the 50-watt size for the 230-volt class. To meet the demand for an ordinary type of white lamp in a size larger than the 50-watt, the 75-watt lamp is now available in a bulb coated with a white material which thoroughly diffuses the light, and has an absorption value of only about 10 per cent. The committee of the Association of Railway Electrical Engineers on Train Lighting Equipment recommended[37] in their last semi-annual report that "it is desirable to reduce the number of kinds of lamps used for train lighting purposes to a minimum consistant with meeting the requirements for illumination of the various classes of passenger train cars." Lamps for 30 to 34 volts and of 15, 25, 50 and 75-watt sizes were specified in the report which is to be submitted to the membership for approval.

The projector-type of incandescent lamp has been in use in this country for several years, and such lamps are now appearing in Germany[38] in a design somewhat different from those made here. The usual heavy spiral-wire filament wound in the ordinary flat grid form is supported by a ring of refractory material which is mounted either vertically or horizontally to meet the need for either type. The sizes reported range from 60 to 1,500 watts.

Properties.—In an investigation of crystal growth during burning, in tungsten filaments and those containing up to 1 per cent of a refractory oxide such as ThO_2,[39] the deformation of the fila-

[35] *Ill. Eng.*, Nov., 1921, p. 225.
[36] Report of Lamp Committee N. E. L. A., May, 1922.
[37] *Rlwy. Elec. Eng.*, July, 1922, p. 226.
[38] *Helios*, Apr. 9, 1922, p. 1,192.
[39] *Chem. Abs.*, Oct. 20, 1921, p. 3,424.

ment during life was found to be a function of this growth which is suppressed in the thoriated filament but appears when the amount of ThO_2 is reduced. Traces of common gases when present in the lamps act as follows: oxygen forms W_2O_5; water vapor forms WO_n at the high temperature parts of the filament which is reduced to W by H at the cold parts: CO_2 attacks the hottest parts of the filament forming a dark blue oxide: Hydrocarbons convert the surface of the filament into tungsten carbide Experiments made[40] on drawn tungsten wire in the same way as those of Weissenberg, show that in the filament the crystals are so arranged that the faces of the rhombic dodecahedra, are at right angles to the axis of the wire. The drawing does not appear to effect the lattices which are the same as those of powered tungsten of different origin.

Additional work[41] on the brightness of light sources has resulted in values for tungsten, lamps given in the following table to which are added for comparison purposes those for the kerosene flame and the carbon filament.

Source	Brightness candles per sq. cm.
Kerosene flame	1.3
4 W. p. c. carbon filament	51
0.9 W. p. c. tungsten filament	227
Same lamp frosted	2.5
50 Watt white "Mazda"—outside	120
50 Watt white "Mazda"—filament	408
2,000-Watt "Mazda"—outside coil	864
2,000-Watt "Mazda"—inside coil	2,021
Same type lamp frosted—outside	105

Measurements on the brightness of tungsten at various temperatures made by three different methods gave[42]

at 1,000° K.	0.000098	candles per sq. cm.
at 1,600° K.	0.025	candles per sq. cm.
at 2,200° K.	61.7	candles per sq. cm.
at 2,800° K.	670	candles per sq. cm.
at 3,400° K.	3,380	candles per sq. cm.
at 3,600° K.	5,200	candles per sq. cm.

Data have also been obtained[43] on the relation between color temperature and efficiency of the gas-filled tungsten lamps over

[40] *Phys. Zeit.*, Jan. 1, 1922, p. 14
[41] *Jour. of A. I. E. E.*, Dec., 1921, p. 995.
[42] *Phys. Rev.*, Apr., 1922, p. 316
[43] *Jour. of Opt. Soc. of Amer.*, Jan., 1922, p. 10

a range of from 10 lumens per watt to 40 lumens per watt. The following table is taken from the published curve.

Efficiency lumens per watt	Color temperature
12.5	2,750° K.
15	2,820
20	2,950
25	3,090
30	3,260
35	3,460
39.2	3,644

In order to simplify the computations of the characteristics of tungsten lamps a new set of empirical formulae[44] has been worked out. The equation for the relation between voltage v, and specific consumption, e, is given as

$$\frac{v_2}{v_1} = \left(\frac{e_1 - 0.1700}{e_2 - 0.1700}\right)^{0.428}$$

Within the range 0.71 to 1.31 w. p. c., the error in using this formula is said to be less than 1 per cent. The candlepower voltage formula is given as

$$\frac{c_2}{c_1} = \left\{ \frac{\frac{v_2}{v_1} - [0.190 + 0.1\,\epsilon_1]}{0.810 - 0.1\ {}_1} \right\}^{2.834}$$

where c represents the candlepower, v the voltage and ϵ the efficiency. $\epsilon = e_1 - 1$ if e_1 is the initial efficiency. The simplification in these formulae seems to lie in the elimination of the reduction to normal values which the best previous equations have required.

The importance of cleaning lamps and glassware has[45] frequently been emphasized but always from the standpoint of efficiency and conservation of the light flux. An investigation has been carried out on the possibilities of injury due to electric potential from contact with dirty lamp bulbs. Determinations were made by three different methods of the difference of potential between the lamp base and various points of contact on the bulb. Lamps with various kinds of superficial coating were tested and it was found that on dirty bulbs it is possible on 230-volt circuits to get leakage which may be dangerous.

[44] *Jour. of A. I. E. E.*, Dec., 1921, p. 905.

[45] *E. T. Z.*, June 15, 1922, p. 815.

ARC AND VAPOR-TUBE LAMPS

Few developments have been announced in the field of the ordinary arc lamp and those which have appeared seem to be in the types used for special purposes rather than for general illumination. For instance, improvements have been reported[46] in the Beck searchlight arc. In the 150-ampere size the electrodes are only 16 mm. in diameter as compared with 36.5 mm. in the ordinary carbon arc. In this lamp the arc plays in an atmosphere of illuminating gas and the crater is often 15 mm. deep. A 225-ampere size, recently developed, is said to have a surface brightness of 1,250 hefner candles per sq. mm. which is seven times that of the ordinary arc or about equal to that of the Lummer high pressure (6 atm.) arc. The positive carbon is enveloped by a refractory tube which insures a CO atmosphere at the tip of this carbon. It is claimed that if the 300-ampere unit were set up at a distance equal to that of the moon it would appear as bright as a star of the sixth magnitude.

Type.—There are some features[47] in a recently produced tungsten arc which distinguish it from those now in use. A funnel-shaped screen is provided on which the evaporated and sputtered tungsten is deposited in order to prevent blackening of the bulb. The arc discharge takes place between small tungsten spheres in an atmosphere of rare gas. The lamp is available in the small sizes, and in the one-ampere unit the spheres have a diameter of about one millimeter, whereas in the 2.5 ampere unit they are nearly 2 mm. in diameter. The distance between the spheres and the glass wall of the bulb may be as small as 2 to 2.5 cm. so that when used for projection purposes, small focus condensers may be employed. The brightness of the sphere is given as about 14 c. per $mm.^2$ The lamps are designed for 200-volts on a.c. circuits and can be run with no other auxiliary appliance than a series resistance. A new tungsten arc has been reported[48] in Holland which is designed for 220-volt a.c. at 50 cycles and gives 1.5 candles with a consumption of only 3 watts. It is described as a metal filament lamp in which the filament is wound back and forth between supports in the usual manner.

[46] *Elek. Zeit.*, Nov. 17, 1921, p. 1,316.
[47] *Elec.*, Dec. 30, 1921, p. 828.
[48] *L. u. L.*, Mar. 23, 1922, p. 143.

Characteristics.—The color temperature of the crater of the carbon arc has been measured[49] and found to be 3,780° K. for solid and 3,420° K. for cored carbons. The above measurements were made on a 65-volt, 10-ampere arc. An additional study has been made[50] of the low-current arc between electrodes of various metals, and the relation found between potential and current for values up to 0.5 amperes in the case of C, Ag, Cd, Cn, Fe, Sn, Zn, Se, and salts of Ba, Ca, Cs, Na, and Sr. As the current is increased the glow arc changes suddenly to the true arc form and at the same time the cathode arc drops sharply, in the case of Ag, Cn, and Fe changing from 214 to 28 volts, from 290 to 16 volts, and from 205 to 24 volts respectively. These metals all gave the glow discharge up to 0.1 amperes.

Using an acetylene flame[51] as a comparison source additional experiments have been made on the spectral distribution of the carbon arc. Cored carbons were employed, taking 5.7 amperes. The curve obtained agrees quite closely with a black-body at 3,325° K., computed from Wein's law. The difference between these results and previous work is attributed either to the supposition that the cored carbons used burned at a lower temperature; (the carbon arc has been assumed to radiate like a black body at 3,750° K.), or that it is caused by the absorption band that has its center at 0.60 μ, when the arc is at 2,360° K. At the temperature of the arc flame this absorption band would suffer a shift toward the violet.

Vapor.—The past year has seen a very marked growth in the use of the neon vapor-tube lamp, particularly, in the low candlepower sizes. The development of this lamp has been rapid and it is available for both lighting and sign purposes.[52] In the former case one electrode takes the shape of an open type wire spiral. In the sign lamps one electrode is a metal plate in the form of a letter of the alphabet. The lamps are designed for both a.c. and d.c. on 200 and 250-volt circuits. In the d.c. type the light is emitted from one electrode only and hence the polarity must be considered. The theoretical life is over 5,000 hours[53]

[49] *Jour. of Op. Soc. of Amer.*, Jan., 1922, p. 41.

[50] *Astrophys. Jour.*, Nov., 1921, p. 273.

[51] *Nature*, July 21, 1921, p. 648.

[52] *Ill. Eng.*, Dec., 1921, p. 243.

[53] *Elec. Rec.*, Oct., 1921, p. 234.

and some manufacturers guarantee 2,500 hours. An application of these lamps as pilot lights has again been suggested.[54] In the case of electric furnaces one neon lamp, in parallel with the heater winding, would show when the current was on and help to obviate leaving it on when it should be off. The resistance is so high and the current consumption can be made so small (less than one milli-ampere with a 20,000 ohm series resistance) that the power loss is negligible. With electrically heated thermostats, incubators, etc., where the means of heating are not directly visible, the neon lamps serve to indicate contact when making adjustments, while a second lamp shunted across the contact breaker reduces arcing.

Among the curious properties of the neon glow lamps[55] may be mentioned a so-called "blinking" with constant frequency, when the lamp shunted by a condenser is connected in series with a 200-volt d.c. circuit . The explanation lies in the fact that the lamp is a non-conductor below 145 volts. If the resistance in series is sufficiently high the condenser will take an appreciable time to charge and no current will pass through the lamp and condenser until the voltage reaches 150 volts. At this voltage the lamp starts to conduct and partly discharge the condenser until its voltage drops to 145 volts when the lamp again becomes non-conducting. The cycle is repeated indefinitely at a frequency depending on the relative values of condenser capacity and resistance. The same effect can be obtained by connecting a neon lamp and condenser in series on a 220-volt d.c. circuit.

Other properties of this lamp are: lighting to almost full brilliancy from an ordinary telegraphic magneto; glowing when the plate of an electrophorus is discharged through it; glowing when the bulb touches a high potential bus bar, thereby indicating that it is "alive;" glowing in a dark room if rubbed by hand. When a condensor is discharged through a neon lamp the discharge is not oscillatory, neither is the condenser completely discharged.

The experiments on the cathode glow lamps[56] have indicated that although low starting voltages are characteristic of the alkali metal electrodes such electrodes are not satisfactory be-

[54] *Nature*, May 27, 1922, p. 683.

[55] *Elec. Rev.*, (*L.*), June 23, 1922, p. 875.

[56] *Zeit. f. Tech. Physik.*, 3, 1922, p. 61.

cause of their tendency to sputter and evaporate. Electrodes of pure iron or tungsten when in the form of fine wire and gauze and made thoroughly gas free will operate on a starting voltage as low as 110-volt with a direct current circuit. A method of starting[57] mercury vapor lamps which eliminate the necessity for hand or electromagnetic operation employs a coiled tungsten filament in a glass tube containing mercury and an inner gas. Current through the filament heats the gas which expands and causes the mercury to move enough to start the arc.

LAMPS FOR PROJECTION PURPOSES

In this class of lighting units the greater number of improvements seem to be in those used for automobile work and in miner's lamps. Quite a number of new fittings for flashlights have been announced but the improvements are of a general rather than of a radical character.

Hand Lamps.—A new flashlight[58] is provided with three lamps which may be used independently or all together, continuously or intermittently. For signal purposes red, green and clear bulbs may be used. An improvement in the little flashlight which derives its current from a hand operated dynamo[59] consists in the addition of an extension outfit which permits the user to have light at two points at the same time. Another modification employs a tripod so that the dynamo can be run by foot power leaving the hand free.

A hand lamp for use, particularly, in factories[60] and shops utilizes the lamp current to energize a magnet placed in the bottom of the socket holder. This makes it possible to have the lamp supported by a convenient piece of metal such as the column or the bed plate of a lathe. The small button in the lamp base disconnects the magnet when it is desired to move the lamp.

Automobiles.—In a discussion of automobile headlights[61] before the English I. E. S. it was suggested that a headlight beam should have three parts: a fairly wide relatively dim beam with a well defined upper limit, 3 to 4 feet from the ground so as to illum-

[57] *Pop. Mech.*, Aug., 1922, p. 182.
[58] *Elec. Rec.*, Dec., 1921, p. 395.
[59] *Pop. Mech.*, Nov., 1921, p. 706.
[60] *Elec.*, Dec. 16, 1921, p. 763.
[61] *Ill. Eng.*, Apr., 1922, p. 88

inate roadways, ditches, etc., in front of the car; a central broad but shallow pentrating beam of much greater intensity for illuminating the road well ahead with the same upper defining limits; finally, a relatively diffused and subdued beam of very wide angle, which is of less importance than the first two.

In the class of automobile headlights[62] is one which obtains its effect by altering the curvature of the reflecting surface of the ordinary parabolic mirror. The upper part is dished so that it is inclined to the main axis of the lamp. The angle of the beam is such that it is said to cover 30 feet at 50 yards, while good visibility is obtained at 100 feet. A special form of gas-filled lamp is used having a concentrated helical filament. Another automobile headlight endeavors to eliminate glare by using a tapered tube 10 inches long[63] fitted at the end with two D-shaped lenses and having a horizontal diaphragm which divides the whole length. At the lamp end is a reflector. The lamp beam can be made narrow and intense, or wide and less intense by varying the contraction.

Developments[64] are being made in automobile parking lamps as well as in headlights. A new type is barrel-shaped with a lens at each end, one clear for forward use and one red for light at the rear. The cover snaps off making the socket easily accessible. A signal light for autos is intended[65] to be mounted on the windshield and has two parts. The upper lens is provided with a stationary light and revolving colored lenses which produce a signal said to be visible for a mile or more at night. Below is a direction signal visible from front and rear, the letters "R," "L," "S," indicating right, left and stop respectively. The neon discharge tube[66] has been adopted for an automobile stop-signal device. The tube is made in the form of a human hand, and glows with the characteristic neon red when the circuit is closed by pressing a button on the steering wheel.

Searchlights and Spot Lights.—Information has been published[67] of the performance of an improved searchlight put forward in the summer of 1918 by the German War Department.

[62] *Ill. Eng.*, Dec., 1921, p. 242.
[63] *Ill. Eng.*, Dec., 1921, p. 242.
[64] *Pop. Mech.*, May, 1922, p. 712.
[65] *Pop. Mech.*, March, 1922, p. 340.
[66] *Pop. Mech.*, Nov., 1921, p. 645.
[67] *Sci. Abs. B.*, Jan. 31, 1922, p. 69.

The effective candlepower in the center of the beam is given as from 422 to 485 million hefner candles, the total weight as 75 kilograms. The radiation at 0.64 μ is equal to that of a black body at approximately 4,660 to 4,860° C., and the minimum burning period is 2 hours, with a changing over period of 70 seconds.

The demands of the motion picture news-reel reporter[68] are such that a portable arc has been designed which is light enough to be carried by hand and gives a powerful beam with a small current consumption.

Designed especially for show-window illumination[69] a recent spotlight is fitted with a 250-watt lamp and is adjustable to any angle or direction. It is fitted with a yoke which makes it possible to attach the unit to a 3.25-inch shade holder of the regular window reflector or bolt it to any supporting surface. Spread of the spot is provided for and also the use of colored media.

A new combination spot flood-light[70] unit has been designed for service up to 200 feet. It has a framing shutter, by which any area can be exactly covered, built in so that it does not interfere with the operation of the color wheel, iris shutter or other equipment. The arc equipment will take care of 40, 60 or 80-ampere carbons and a 6-inch diameter lens of long range focus is furnished to correspond to the long range adjustment of the arc lamp.

The stroboscopic principle which has found so many applications in physics has been applied[71] in an apparatus which is intended for the study of rapidly moving objects. Thus when light from the device is directed on to the needle of a sewing machine the apparent speed of the needle is slowed down to such an extent that every detail of the movement is visible. The lamp is made to give intermittent light in flashes with a period of about one-millionth of a second.

Signalling.—The largest installation outside of this country of colored-light railway signals to be used in the day time is now claimed[72] for the re-equipped system of the Liverpool (England)

[68] *Pop. Mech.*, July, 1922, p. 48.
[69] *Elec. Merch.*, Feb., 1922, p. 109.
[70] *Elec. Rec.*, Jan., 1922, p. 22.
[71] *Elec. Times*, Apr. 20, 1922, p. 401.
[72] *Elec. Rlwy. Jour.*, Dec., 1921, p. 1,150.

elevated system. It is said that the signals can be seen for 3,000 feet even in the brightest sunshine.

The committee appointed by the British Ministry[73] of Transport to investigate this type of signalling has presented a report after visiting the installation referred to, and that of the London and Southwestern Railway. Of the two systems in use, *i. e.*, red, green and yellow lenses, and, a series of white lights simulating semaphore positions, the committee was of the opinion that the former was better as regards practicability, first cost and maintenance. The committee also came to the conclusion that three sets of light signals should be sufficient to cover all requirements.

Reference should be made to the proposed standardization of these lights in the May issue of this Society's TRANSACTIONS.

It might be noted that in connection with other changes in railway signal lighting,[74] yellow instead of white is used for the "clear" signal on railroads of this country. White means a broken glass, and indicates "stop."

The traffic control problem is constantly increasing in importance as the older methods involving semaphores and mere signs are found to be inadequate for city conditions. The committee on standards of the American Association of State Highway Officials has obtained[75] endorsements of over 200 cities and a large number of auto clubs and national associations to their recommendation that red, yellow and green be used in road traffic to indicate respectively, "All traffic stop," "Proceed with caution" and "Road intersection dangers."

A new guide[76] consists of a combination of three lights each of a different shape; a round red light, a rectangular white light, and a dome-shaped green light. The signal is intended for suspension above the street and to be visible in all directions. Another street traffic signal is[77] fitted with only two display sides in place of four. It is designed to be placed about 7½ feet above the sidewalk, offering no obstruction to traffic and from any one street only one color or signal can be seen at a time. The signals are located at street intersections, two being used where

[73] *Elec. Rev.*, June 16, 1922, p. 858.
[74] *Science News Letter*, Mar. 6, 1922, p. 11.
[75] *Safety Eng.*, Sept., 1921, p. 126.
[76] *Elec. Wld.*, June 17, 1922, p. 1,250.
[77] *Elec. Rev.*, Apr., 1922, p. 250.

the traffic is light and four where it is heavy. It is arranged with two tiers of lenses, each tier showing red and green in reverse directions, each pair being in a separate compartment and illuminated by only one lamp at a time. It is only necessary to light the top lamp in one tier and the bottom in the other to reverse the signal, instead of turning it around. It is said to be easily read in full sunlight for a distance of two blocks.

Details have been given[78] of a signalling device developed before and during the war which utilizes radiation in a narrow region of the spectrum just beyond the violet (0.40 to 0.35 μ). A mangin mirror reflects sufficiently well in this region to permit the use of an ordinary automobile headlight lamp. A special glass filter to cut off visible radiation was designed and an extended investigation led to the use of a barium-platinum-cyanide fluorescent receiving screen which fluoresces with a considerable intensity even under weak stimuli. One of the great advantages of this system is the fact that glass is quite transparent to radiation in this part of the spectrum and hence the receiving screen can be used with an ordinary prism field glass. In practice two telescopes are fixed side by side, one for transmitting, the other for receiving. In the former are mounted duplicate lamps, the filter, eyepiece, and transmitting lens. The latter contains a condensing lens with the fluorescent screen at its focus, and an eyepiece. The beam received appears in the eyepiece as a little green moon which blinks its signals.

The use of incandescent lamps for indicating purposes in industrial and other mechanical operations is common. A quite unique application[79] of this idea is the use of a column of 15 lights connected to the bellows of a master player-piano to show tonal intensity. The bellows are actuated by holes in the tracker bar which in turn are controlled by perforations in the music roll. The number of perforations determines the loudness of the tone and turns on a definite number of lights. In this way 15 degrees of intensity ranging from pianissimo to fortissimo may be shown.

Lighthouses.—A French lighthouse[80] when provided with metal mirrors instead of Fresnel prisms was found to have an apparent candlepower as measured in the laboratory of 163,500. The light

[78] *Elec. Wld.*, Aug. 13, 1921, p. 307.
[79] *Pop. Mech.*, Apr., 1922, p. 500.
[80] *C. R.*, Jan. 30, 1922, p. 289.

was visible in clear weather a distance of 33 miles and in exceptionally clear weather as far as 41 miles. Assuming 91.6 to be the percentage transmission per kilometer of air for a light of the same type fitted with Fresnel prisms, the apparent candlepower was computed as 70,000. This means that the metal mirror type has an apparent effectiveness over twice that of the usual construction.

Ordinary maritime lighthouses having an effective projection of from 40 to 60 kilometers, are far too feeble for aeronautic purposes owing to the speed of an airship's flight (200 km. per hour) and the distance from the ground (not less than 2.5 km.) The Technical Aeronautic Service of France has constructed[81, 82] a lighthouse, with a rating of 1,000 million beam candlepower, on the top of Mount Afrique near Dijon. It is claimed to be more powerful than any now existing, and in clear weather will be visible at 150 km. and under specially clear conditions 300 and possibly 400 km. The structure houses eight projection systems of the Fresnel type, each consisting of a panel containing seven dioptric and ten catodioptric elements. At the center of each of these lens systems (50 cm. focus) is a horizontal d. c. carbon arc, entirely automatic, the positive carbon having a continuous rotative movement. The eight optical sets are arranged in groups of four on two platforms and are contained in a lantern of 5.5 m. in diameter. The rays from each group converge at a certain distance into a single beam.

A beacon light has been constructed[83] for installation on the top of a building in a middle western city. It consists of two units equipped with Fresnel lenses and 300-watt concentrated filament gas-filled tungsten lamps spaced sufficiently far apart not to blend. The framework is built of solid bronze and is weather proof. The beacon will be 300 feet above the street level and is expected to be distinctly visible at a radius of five miles and at double this distance on especially clear nights. It may be used for signalling and for blinking the time as well as for a beacon.

Miners' Lamps.—Up to November, 1921, the Miners' Lamps Committee of England had issued five memoranda,[84] the last two

[81] *La Genie Civil*, Dec. 24, 1921.
[82] *Elec. Wld.*, Feb. 18, 1922, p. 342.
[83] *Elec. Rec.*, Dec., 1921, p. 407.
[84] *Nature*, Feb. 23, 1922, p. 831.

dealing with the use of perforated metal plates and chimneys, respectively, for flame lamps. The addition of a short glass cylinder, known as the "combustion tube," to the end of a metal chimney suspended directly above the flame promotes better circulation in the lamp, isolates the products of combustion and results in stronger and better light. This device is growing in favor.

Memorandum Number 6 has since been issued[85] and covers the lamp-room organization and the upkeep of safety lamps.

The number of electric lamps used in British mines in 1920[86] was 245,900 compared with 197,722 in 1919. Over the same period there was an increase in the number of lamps fitted with the magnetic method of locking of some 46,000. Up to April, 1922, twenty-six types of miners' lamps had been approved[87] by the English authorities and thirteen for use by officials and for special purposes only. A recently approved design consists of a pressed steel lead-lined accumulator case, strengthened by transverse ribs, a two-cell battery with equipment to use either solid or liquid electrolyte, a lantern having a dome-like reflector with its bulb protected by a cover glass and four steel pillars; and a magnetic lock. Another approved type[88] has two lamp bulbs connected in parallel in an insulated plate in which are imbedded brass segment-contacts.

The workers-and-employers division of the[89] "Arbeitskammer" for the coal miners in the Ruhr region has adopted a resolution stating their conviction that the introduction of electric miners' lamps cannot be generally followed in this locality.

One of the objectionable features of acetylene safety lamps for miners[90] has been the necessity of using a wire to clear the burner of soot. This has been eliminated in a new lamp in which the clearing is accomplished by merely pressing a button.

Projection.—In optical projection systems the usual arrangement places the source of light at the focus of the first lens. A novel modification[91] places a real image of the source at the focus and thus permits of the employment of as many sources as desired.

[85] *Elec. Rev.* (*L*), Mar. 3, 1922, p. 305.
[86] *Elec. Wld.*, Mar. 18, 1922, p. 551.
[87] *Elec.*, Apr. 28, 1922, p. 507.
[88] *Elec.*, Feb. 3, 1922, p. 137.
[89] *E. T. Z.*, Jan. 12, 1922, p. 58.
[90] *Pop. Mech.*, Jan., 1922, p. 116.
[91] *E. T. Z.*, July 28, 1921, p. 831.

The result is an effective source, almost equal in intensity to the sum of the actual sources. Elliptic mirrors produce the images. This is a modification of an idea already adopted in moving picture projection where images of the spirals of an incandescent lamp filament are reflected by means of a mirror back to positions between the original filament parts, thus producing a more solid source as well as considerable additional intensity.

STREET LIGHTING

According to the Lighting Sales Bureau of the National Electric Lamp Association[92] street lighting during the past year was "the only phase of electric lighting activity in which the progression was unimpeded."

Very encouraging interest has been shown[93] by small cities and towns throughout the middle west in improved ornamental street lighting. Many which have never had any form of street lighting other than low intensity, overhead fixtures at street intersections are interested in the new ornamental fixtures, while the old style cluster posts operated on low-voltage multiple circuits are being replaced by single-lamp units. Progress is also being made in the south-west[94] where it is reported that throughout a section containing one and a half million people, ornamental street lighting to the cost of about two million dollars is under construction and in prospect.

The fact may be noted[95] that the use of mantles in gas street lighting began in 1896 with the installation of 285 lamps. By 1914 this number had grown to over 230,000.

The Committee desires to reiterate the recommendation made in last year's report[96] that the proper committee prepare and standardize a model for listing information on street lighting in such shape that further reports on this subject may be more comprehensive, and that these forms be distributed to engineers in various cities in charge of illumination.

Reports have been received from engineers in a number of the larger cities and have been incorporated in the following descriptions of specific installations:

[92] Report of Lighting Sales Bureau, N. E. L. A., May, 1922.
[93] *Elec. W'ld.*, Dec. 10, 1921, p. 1,178; Apr. 22, 1922, p. 806.
[94] *Jour. Elec. and West. Ind.*, Nov. 1, 1921, p. 344.
[95] *Gas Age Rec.*, Feb. 25, 1922, p. 230.
[96] TRANS. I. E. S., Oct. 10, 1921, p. 194.

Western Coast.—In Seattle very little extension work has been going on, but one hundred and fifty 80 cp. and sixty-two 400 cp. tungsten lamps have been added to the street circuits. There is also under construction one-half mile of ornamental lighting using 250 cp. lamps in the University District. The city of Portland installed four hundred new arc lights.

The greatest changes have apparently been made in San Francisco. At one time there were over 8,000 gas lamps. This number has been reduced to less than 5,000. Replacements are being made with 250, 400, and 600 cp. incandescent electric lamps in band refractors. All of the old a.c. arc lamps have now been replaced by either luminous arcs or mazda lamps. The former is used only in the post type and for decorative purposes. The latter type has replaced the suspended magnetite lamps.

From highway engineering records[97] in various counties in California it has been established that the growth in traffic has been taking place at the rate of 300 per cent in seven years. It has been estimated that 35 per cent of all automobile traffic occurs between the hours of 6 P. M. and 6 A. M. As a consequence the value of highway lighting is evident. A study of the lighting in one county showed more than 5,000 units spread over 186 miles of roadway. The lights had been installed at different times under varying conditions and presented an excellent illustration of the desirability of having such work designed and installed by competent engineers. Some of the installations could not be used because of their unfitness, and in some cases the expense of maintenance was far in excess of that necessary to take care of an up-to-date system.

Middle-West.—The completion of the extension of Salt Lake City's "white way" lighting system was celebrated October 5, 1921.[98] The new installation consists of three hundred and thirty-six 6.6 ampere luminous arcs, of 1,500 cp. each, on steel ornamental standards, three lamps to a pole, the top one 25 feet above the street and the other two 18 feet. Plans are being formulated to light many more city blocks in a similar manner.

At Twin Falls, Idaho,[99] the equipment having been on hand for some time, authorization has been obtained for the installation of 108 ornamental curb lights along two of the main streets.

[97] *Jour. of Elec. and West. Ind.*, Jan. 15, 1922, p. 42.

[98] *Elec. Wld.*, Oct. 22, 1921, p. 837.

[99] *Elec. Wld.*, Aug. 13, 1921, p. 335.

The Committee appointed to study the street lighting in Minneapolis, Minnesota,[100] has recommended that the control of the street lighting be placed in the hands of an electrical engineer. The report of the Committee discussed a system which would give fairly uniform illumination on the street surface and would have an intensity graded according to the night traffic. One way of obtaining the result would be the replacement of the present 15 ft. standards spaced at 100 or 120 feet by 30 ft. standards spaced at 240 feet. The proper use of heavy durable globes was recommended to eliminate the glare.

Central States.—The street lighting of East Cleveland has been completely rejuvenated by the replacement of all old gas and arc lamps by gas-filled incandescent lamps. A total of 900 units was put in, ranging from 200 cp. on purely residential streets to 1,000 cp. on busines thoroughfares. The lamps are carried by brackets mounted on poles a 4.5 ft. bracket on residential streets and a 6 ft. bracket on the business thoroughfares. The lamp heights are 16 feet and 20 feet. A distinctive feature of this installation is that, in order to avoid the necessity of putting in additional circuits, the lamps used in the residential districts are all of the 110 volt multiple-type, fed from secondary circuits already supplying residential needs. The new system was inaugurated by a celebration on March 27, 1922.

Changes in Cleveland are indicated in the following table:

Size and type of unit	Number June 1, 1921	Number June 1, 1922
6.6 Amp. carbon arcs	280	—
4 Amp. magnetites	920	905
20 Amp. 600 cp. tungsten	944	1,384
20 Amp. 1,000 cp. tungsten	607	924
20 Amp. 1,500 cp. tungsten	310	424
750 Watt multiple	0	0
Total	3,079	3,646

At Marion, Illinois,[101] a cluster-post system has been replaced by single lamp posts equipped with 2,000 lumen, 6.6 ampere series incandescent lamps in opal globes. Two circuits are used one burning all night and the other part of the night. The posts are cast iron, 11 feet (3.3 m.) in overall height which was found to harmonize best with building heights.

[100] *Elec. Wld.*, Dec. 24, 1921, p. 1,291.
[101] *Elec. Wld.*, Dec. 10, 1921, p. 1,177.

A modification of the group ornamental lighting system used in Chicago has been adopted at Champaign, Illinois,[102] where 539 standards will be installed.

Southern States.—Since June, 1921, the only new developments in street lighting at New Orleans, Louisiana, have been the installation of twenty-nine overhead service-fed arc lamps and one underground service-fed arc lamp. The following table gives the street lighting condition in June, 1922:

Number of miles of improved streets illuminated	261
Number of miles of unimproved streets illuminated	469
Number of miles of streets not illuminated	324
Number 5.5 amp. magnetite arc lamps underground circuits	522
Number 5.5 amp. magnetite arc lamps overhead circuits	2,957
Number White Way Double Light Standards (250 cp., 7.5 amp.) tungsten lamps	333
Number underground 100-watt tungsten lamps	8
Number White Way Single Light Standards (250 cp.) tungsten lamps	1,728

South-eastern States.—The great causeway connecting Miami, Florida, and Miami Beach has been lighted[103] throughout its whole extent; two hundred and fifty cp. 6.6 ampere tungsten lamps are used, mounted on pole extensions which bring them 30 feet above the roadway and are spaced at 400 ft. intervals except on curves where the spacing is 300 feet. An ornamental lighting system[104] has been installed on the main business street of Danville, Virgina.

There are about 10,000 gas street lamps in Washington, D. C.,[105] and an effort to have these replaced by electric lamps was checked as a result of a public demonstation in which the old upright type of mantle unit was replaced by double inverted-mantle fixtures enclosed in clear-glass lanterns, corresponding in design to that of the standards. It was decided that the dual system of street lighting was advantageous. A similar decision had already been made in Baltimore and Pittsburgh.

[102] *Elec. Rev.* (U. S.), Nov. 12, 1921, p. 747.
[103] *Elec. Rec.*, June, 1922, p. 385.
[104] *Elec. Rec.*, Mar., 1922, p. 201.
[105] *Am. Gas Jour.*, Feb. 18, 1922, p. 168.

Eastern States.—No increases are reported in the number of incandescent tungsten lamps in the city of Philadelphia during the past year, but at scattered locations throughout the city three hundred and forty arc lamps have been installed. An ornamental "White Way" lighting system has been authorized[106] for Main Street in the business district of Webster, Massachusetts.

In three ways the new lighting system of Stamford, Connecticut,[107] is an improvement over the old system, namely, in the use of better fixtures, through better distribution and more available light. This has been accomplished through the use of one hundred and fifty 6.6 ampere magnetite arcs placed in ornamental panelled globes, spaced 100 feet apart and staggered. Eighty lamps of the earlier system were retained for the outer zone of the arc lighting area, and nine hundred and thirty-one vacuum incandescent lamps formerly used there were replaced by nine hundred and sixty 100 cp. 6.6 ampere gas-filled tungsten lamps. Two circuits are used so that after midnight one can be cut out.

Additional new lights have been provided[108] for on twenty-six city streets of Worcester, Massachusetts, while at Spencer, Massachusetts, lights will be placed on the street connecting it with Leicester Center. This will complete the lighting of the highway between the two cities.

The following table shows the lighting situation in the city of Boston up to and including June 1, 1922.

Magnetite arc lamps	800 cp.	Series*	5,409
Magnetite arc lamps	800 cp.	Multiple	25
Incandescent	40 cp.	Series	1,903
		Multiple	1,432
	60 cp.	Series	751
	100 cp.	Series	5
		Multiple	15
	200 cp.	Series	10
		Multiple	11
Gas-open flame F. A.			108—32 Welsbach
Single Mantel Gas Welsbach 60 cp.			9,068

*White Way Lamps included.

New York City reports that at the close of the year 1921, 79,340 lamps were in service on the streets and in the parks of which 9,012 were gas, twelve were naphtha and the remainder were

[106] *Am. Gas Jour.*, Apr. 22, 1922, p. 384.
[107] *Elec. Wld.*, Oct. 29, 1921, p. 861.
[108] *Am. Gas Jour.*, Nov. 5, 1921, p. 428.

electric lamps. This represents a decrease of 1,563 gas lamps and an increase of 2,164 electric lamps from the number in service at the beginning of the year. The total number of new street lamps installed was 2,427. Four thousand seven hundred and sixty-eight other changes were made either to improve the lighting, or on account of public improvements or changes in the distribution system. The principal extensions were made in the Boroughs of Brooklyn and Queens where an increase in public improvements and in building construction necessitated an increase in illumination.

A decided step forward[109] is evidenced in the township of Amherst, New York, which is adjacent to Buffalo. All the highways in the township are to be lighted, making a total of about 100 miles. The complete installation will consist of between 1,000 and 1,500 units including those to be placed along a portion of the Buffalo-Niagara Falls Highway. It is expected to have the work completed in three years, but 212 units are to be installed first along 5 miles of the East and West Highway[110] leading out of Buffalo, one of the great motor truck travel routes, as well as along a number of parallel stretches of improved roads and cross roads. The units along Main Street will be spaced at intervals of approximately 400 feet, placed 30 feet above the road surface and about 20 feet back from the curb.

Canada.—Toronto, Canada, with some 60,000 lights on multiple circuits[111] has installed on the water front boulevard its first series-system consisting of six hundred cp., 20 ampere lamps on ornamental poles with the light center 15 feet from the ground, and opposite. The lamps are enclosed in octagonal cast-bronze lanterns equipped with opalized stippled-glass panels and containing a one and one-half inch dome refractor with porcelain-lined reflectors.

As the finishing touch to a long list of improvements[112] the town of Montreal West has put in a lighting system covering about nine miles of thoroughfares. Two hundred and eighty-eight cast iron standards equipped with 250 cp. 6.6 ampere tung-

[109] *Southwest. Elec.*, Apr., 1922, p. 24.
[110] *Elec. Rec.*, May, 1922, p. 307.
[111] *Elec. News*, June 15, 1922, p. 39.
[112] *Elec. News*, Oct. 15, 1921, p. 30.

sten lamps in diffusing glass globes with porcelain-lined reflectors have been installed. The light centers are 12 feet from the ground and the spacing is 150 feet staggered, except on the business streets where 100 ft. spacing is employed.

Great Britian.—In England[113] the resumption of full street lighting conditions has apparently been slow, and it has been said that much of the public street lighting is no better than it was in 1914.

In 1920 at Newcastle-upon-Tyne[114] 1,000 upright gas burners were replaced by the inverted type and a report has been made of the result of the change. It states that a higher standard of illumination has been established together with a considerable saving in maintenance. The total cost per annum for the upright mantle burners is given as 3,633£—as against 910£ for the inverted. The average number of burners used per annum was 47.9 of the upright, and only 29.7 for the inverted. The saving in cost of gas used amounted to 2,584£, making a total saving of 530£. The cost of conversion, which was spread out over a period of two years, was given as 2,431£.

The report of the lighting engineer of Liverpool[115] for the year 1921, shows a net increase of 7 miles of roads lighted, due in large measure to the improvements on various housing estates. Of the 20,140 gas lamps fixed, 12,512 are in the old city, and 7,628 in the suburbs. Approximately 6,000 gas lamps have been converted from the upright to the inverted mantle type and this conversion is continuing at a satisfactory rate.

In the Oxford District in the Borough of St. Marylebone, 500-watt units have been replaced by 1,500-watt lamps, mounted in new lanterns of ocagonal form fitted with diffusing glass panels. The mounting heights are 25 feet and the spacing 160 feet. The average intensity of lighting is 2.1 foot-candles, the maximum value between posts 0.2 foot-candles.

A report on gas street lighting in London[116] states that little or nothing has been done in the way of improvements on the 1914 system but that that system was of the highest character.

[113] *Elec. Times*, Apr. 6, 1922, p. 111
[114] *Gas Jour.*, Feb. 8, 1922, p. 329
[115] *Gas Jour.*, Apr. 26, 1922, p. 213.
[116] *Gas Jour.*, Mar. 22, 1922, p. 718

Italy.—The first attempt at public lighting in Turin, Italy,[117] was in 1911. In 1919 a new program was provided for which has been progressively carried out. Tungsten lamps of 1,000 cp. and 600 cp. (20 amperes) for higher illumination, 7.5 amp. 260 cp. and 100 cp. lamps for lower values have been installed. All lamps are to have reflectors and are to be placed at spacing intervals of 35 and 55 meters and at suspension heights of 4.5 to 7.5 meters.

OTHER EXTERIOR ILLUMINATION

Floodlighting continues to be popular for spectacular purposes in connection with celebrations, fairs, pageants, etc.[118] This form of display together with sign lighting seem to be the two phases of exterior illumination in which there has been the greatest activity, outside of street lighting, since the last report. Sign lighting has assumed such importance[119] that architects are now designing signs in keeping with the rest of the building.

Pageants.—An elaborate floodlighting equipment[120] was used to light "The Pilgrim Spirit," a pageant produced during the previous summer at Plymouth, Mass., to celebrate the centennial of the landing of the Pilgrim Fathers. The pageant was given at night beside the Plymouth Rock and 1,300 performers took part. Fifty specially designed 1,000-watt floodlighting and 48 regular 1,500-watt units were operated in fixed positions at an average height of 50 feet above the field, whose dimensions are 400 feet by 450 feet. Using two parabolic reflectors and an intermedial spherical reflector the divergence of the beams from these units was kept to within seven degrees.

An excellent illustration of co-operation between civic and commercial bodies, and city officials[121] is afforded by the display lighting in connection with Denver's Xmas Tree Celebration. The ornamental lighting standards were clothed with evergreens and the lamps were changed to red and green. One thousand eight hundred vari-colored lamps illuminated the Xmas Tree itself, while from it streamers similarly equipped radiated to nearby points.

[117] *Rev. Gen. d'Elec.*, Jan. 21, 1922, p. 21D.

[118] *Elec. Wld.*, Oct. 29, 1921, p. 884.

[119] *Elec. Merch.*, June, 1922, p. 83.

[120] *Elec. Wld.*, Aug. 6, 1921, p. 286.

[121] *Jour. of Elec.*, Jan. 15, 1922, p. 70.

In connection with the celebration of Armistice Day in Washington, D. C.,[122] a special "Festival of Light" was arranged for, which in its "Jewelled Portal" was said to rival the results obtained at the Panama-Pacific Exhibition. The curtain of this portal was 87 feet wide and with the two obelisks supporting it contained 37,000 "jewels" of which 32,000 were pure crystal and jonquil, and the remainder ruby, aquamarine, amethyst, topaz and emerald. In a great central sunburst on this curtain were outlined the flags of the eight nations participating in the "Limitation of Arms Conference." Thirty-two four-burner Roman lamps in rows with flaring torch-like flames formed an "Avenue of Light" leading to the "Jewelled Portal." Rays from four batteries of searchlights, reflected in mirrors were thrown on the Washington Monument and also, using vari-colored screens, served to light up the clouds of smoke which followed the big gun salutes. From the top of the Monument more searchlights sent out beams illuminating the White House, the U. S. Observatory, etc. The dome of the Capitol was made the center of a fan-shaped display called the "Light of the States." The rays from this display reached such heights above the city that they were visible for miles.

Floodlighting played an important part[123] in the first winter carnival held at Winnepeg, Canada. The "Coronation of the Queen" and her "Evening Court Receptions" were held in a 100-foot space on the steps of the west entrance to the Parliament Buildings (the dome of the newest building being permanently lighted) and were flooded with light from four 1,000-watt units placed 100 feet away. The entire grounds given over to the carnival were surrounded by a wall of ice blocks about 6 feet high and surmounted at 33-foot intervals with ice pillars. To light this wall about 1,500 festoons of 25-watt lamps, red green and white were placed on 2-foot centers. Streamers and festoons were also used to light the main entrance and the band stand, an octagonal shaped building. The ski slides were illuminated by four 1,000-watt units and decorated by streamers running up to the top of the 120-foot tower. About 30 floodlights mostly of the 1,000-watt size were used in the general illumination of the grounds. To typify a future increased power

[122] *Elec. Rev.* (U. S.), Dec. 10, 1921, p. 871.
[123] *Elec. News*, Mar. 1, 1922, p. 18.

supply to Winnepeg a 45-foot steel tower was erected and provided with six 1,000-watt floodlights at the top, while the structure itself was outlined with solid lines of light and wound with bands made up of rows of red, green and white bulbs. About 1,200 sixty-watt lamps were used on this tower.

Buildings.—It seems quite appropriate[124] to have a church tower illuminated on the outside at Xmas time, and in one case, ninety-six 250-watt units were used to flood the four sides with light so that the finest detail was clearly evident.

The floodlighting of the Philadelphia City Hall[125] was displayed on New Year's Eve. Eight batteries of 500-watt units, totalling 300 lamps, were installed in the form of squares around the high tower, throwing this feature into sharp relief against the darkness.

The exterior of the Utah State Capitol Building at Salt Lake City has been illuminated so that it is as prominent at night as it is by day.[126] Starting at the dome is a cluster of fourteen 200-watt lamps on the ball. Four 250-watt lamps are on the cupola while around the upper circle of the dome are twenty-four 60-watt white tungsten bulbs, while the lower circle is lighted by twenty-five 100-watt clear lamps. Straight under the colonnade there are ninety-six 100-watt clear lamps, extending around three sides of the building.

For three nights after the unveiling of the War Memorial Gates at Rugby[127] an impressive effect was obtained by floodlighting with two projectors equipped with gas-filled tungsten lamps. They were fixed at a height of seven feet so as to bring the beams above the head level, and diffusion and sharp cut-off were obtained by the use of diffusing deflectors and a specially designed spill-shield.

Sports.—Lighting a race track is not so very different from lighting a thoroughfare[128] and possibly the arrangement used at the Oregon State Fair may find application elsewhere. Sixty-eight 1,000-watt lamps supported in enameled-steel elliptical angle-reflectors equipped with special hoods were mounted 30 feet above the ground, 10 feet from the edge of the track and in such a way

[124] *Elec. News*, Apr. 1, 1922, p. 45.
[125] *Pop. Mech.*, Mar., 1922, p. 370.
[126] *Elec. Wld.*, Oct. 29, 1921, p. 891.
[127] *Elec. Times*, Apr. 20, 1922, p. 398.
[128] *Elec. Wld.*, Feb. 4, 1922, p. 234.

as to make an angle of about 20° with the vertical. At the curves the spacing was about 240 feet and on the straightaways about 320 feet. The illumination produced at the center of the track ranged from approximately 2 foot-candles, immediately in front of the lamp, to 1.5 midway between poles.

The overhead span-wire suspension system[129] was used to light a city park on the occasion of a "Wild West Show" held at night. The distance across the arena was 365 feet and there were fourteen strings of eight lamps each, suspended over the field which was 700 feet long. Deep bowl porcelain-enameled reflectors each containing a 1,000-watt lamp were used.

The Yosemite Valley has become so popular in the winter[130] that special arrangements have been worked out to make the sports available at night as well as by day. In one place the toboggan slide has been floodlighted.

Commercial.—Floodlighting has been adopted[131] to illuminate the exterior of a large department store in London. A standard design unit having a reflector made of solid copper lined with sectional parabolic glass mirrors is fitted with 400-watt gas-filled tungsten lamps. This is said to be the first example of this type of lighting as applied to large London stores.

An interesting and unique application of floodlighting[132] exists in the illumination of the top, and space above a 257 foot concrete stack used to carry off the fumes from the bags of a lead oxide factory. Any irregularity in the procedure in the bag room whereby the oxide escapes into the atmosphere and is thereby lost, is indicated by a whitish smoke issuing from the stack. To detect this at night a projector equipped with a 500 watt lamp was located on a building about 150 feet from the stack and throws a concentrated beam which adequately illuminates whatever issues from the outlet at the top of the chimney.

To facilitate inspection of high tension lines and switches[133] floodlights of the 500 watt size have been employed, mounted on trunnions which permit of a wide latitude in adjustment.

[129] *Elec. Rev.* (U. S.), Sep. 10, 1921, p. 398.
[130] *Jour. of Elec. and West. Ind.*, Feb. 1, 1922, p. 118.
[131] *Elec. Times*, Dec. 22, 1921, p. 570.
[132] *Natl. Electragist*, Feb., 1922, p. 47.
[133] *Elec. Wld.*, Aug. 13, 1921, p. 332.

Additional details have been published of experiments on the legibility of signs[134] a preliminary discussion of which was given at the last Convention.[135] In considering the effect of various factors on the diminution of the theoretical maximum legibility distribution, attention is called to the diminution which depends on the relative brightness of the sign and of the district and to the partial compensation in the amount of the reduction by a certain degree of atmospheric transmission, when that is low, depending on the absorption and the candlepower of the sign.

The operating expense of signs made up with electric lamps[136] led, initially, to the employment of the low-wattage type, and up to a year or so ago the vast majority of such signs were fitted with 2.5, 5, or 10-watt sizes. Lately, however, there has been a big increase in the number of high-intensity signs fitted with 25-watt, 50, and 75 and in a few instances even 100-watt lamps depending on the brightness of the background and the surrounding area. More attention is being paid to clearness and smoothness of the result obtained, and there has been quite a growth in the use of translucent letters rather than in exposed lamps. In the former case a smaller number of larger and more efficient units will produce the same or even greater brightness than is obtained by exposed lamps. Striking effects have been reached by making up the letters with 75-watt lamps and filling the border with 25-watt lamps. Apparently in England[137] the 10 and 20-watt lamps are still in vogue.

America has been called the "home" of electric sign lighting[138] but great advances are being made in England in this class of advertising, and Piccadilly Circus, London, is said to be rivalling Broadway in its nocturnal displays. There is also a growth in England[139] of the use of electric signs on large vans and delivery wagons. These signs sometimes take the form of posters illuminated by cornice lights and sometimes they are of the moving-letter type.

[134] *Elec. Wld.*, May 27, 1922, p. 1,061.
[135] TRANS. I. E. S., 16, 1921, p. 397.
[136] *Jour. A. I. E. E.*, Feb., 1922, p. 150.
[137] *Elec. Times*, July 6, 1922, p. 15.
[138] *Signs of the Times*, Feb., 1922, p. 54.
[139] *Elec. Times*, Jan. 19, 1922, p. 48.

In order to floodlight a long sign 100 ft. x 6 ft.[140] with only three lamps, an English installation employs special spreading glass fronts which give an elliptical form to the beam. The projectors have 500-watt gas-filled tungsten lamps and are 50 ft. away from the sign which is made up of black letters on a white background.

Aerial.—A paper presented before the English I. E. S. gives considerable information on the present practice of lighting airplanes as well as aerodromes[141] and air routes. Attention is called to the work which has been necessary to fulfil the requirements in the way of high powered lamps and in particular the aerial lighthouses where the necessity for a practicable homogeneous light through 180°, and the avoidance of dark spots has proved a difficult problem.

At Croyden, England,[142] there has been installed what is probably the largest electric sign in the world. It is in the form of a star and measures over a quarter of a mile from point to point. It is used at the aerodrome station to assist pilots in landing during the winter months.

Another aerodrome sign[143] designed for emergency landing is being tested by the British Air Ministry. A large T-shaped steel frame is covered with white canvas, and provided with a vertical fin. It will be mounted on a prominence such as the roof of a small building, and will operate as a weather vane. Acetylene will be used to light this sign at night. The wind strength will be registered and will operate a series of colored lights so that a pilot can determine the course of the wind along the ground.

INTERIOR ILLUMINATION

A review of progress in England in gas lighting for interiors[144] states that as much as 40 candles per cubic foot has been obtained with the latest form of low pressure cluster units. Values are also given for the consumption at ordinary low pressures in cubic feet of gas per hour, per foot-candle, per square foot of surface illuminated for three systems of lighting as follows: for direct

[140] *Elec. Times*, Feb. 9, 1922, p. 140.

[141] *Elec. Rev.*, London, Mar. 24, 1922, p. 428.

[142] *Sci. News Letter*, Mar. 6, 1922, p. 12.

[143] *Sci. Am.*, Apr. 19, 1922, p. 228.

[144] *Ill. Eng.*, Jan., 1922, p. 7.

lighting 0.008 cubic feet; for semi-indirect 0.012; and totally indirect 0.016. With a high pressure system about 0.005 cubic feet is given as the figure for direct lighting. Translated into the modern units the first three values become 255, 170 and 125 lumens per centi-therm per hour. It is suggested that a broad classification of modern gas units might be made on the basis of candle-hours per centi-therm as follows:

Low pressure upright	33 candle-hours per centi-therm
Low pressure Ord. inverted	42 candle-hours per centi-therm
Low pressure cluster inverted	63 candle-hours per centi-therm
High pressure inverted	100 candle-hours per centi-therm

The present practice in England[145] in gas lighting for stores, homes, offices, factories, churches and schools may be found in an address last Spring before the London and Southern District Junior Gas Association. Growth in electric lighting of homes in the U. S. is indicated in statistics obtained from about 70 per cent of the electric light and power industry showing that over one million new residential customers were added during 1921.[146, 147]

Office Buildings.—The trend toward the use of higher illumination intensities is illustrated in the lighting of a large office building.[148] Ten foot-candles was decided on as the requirement for the minimum average intensity. A preliminary investigation and tests were made of twelve types of luminaires and of the direct, semi-indirect and totally indirect systems. It was found that the value 10 foot-candles was exceeded by several of the units, especially when using 200-watt lamps. Some of the better styles of "filtered" direct lighting units gave about 15 per cent higher readings than the semi-indirect and totally indirect luminous-bowl luminaires, while some of the dense direct lighting units gave a lower average than the indirect. As a result of the preliminary tests, 200-watt lamps were decided upon for general illumination and 300-watt units for outlets in drafting rooms. It was found that uniformity of diffusion of light ranged from 20 per cent variation for the indirect to 100 per cent for some of the units in the direct system.

[145] *Gas Jour.*, May. 3, 1922, p. 266.
[146] *Elec. Wld.*, Jan. 7, 1922, p. 11.
[147] *Elec. Wld.*, Jan. 14, 1922, p. 75.
[148] *Elec. Rev.* (U. S.), Aug. 13, 1921, p. 235.

In order to determine the cost of maintenance a careful check was made of the time required to clean the various types of luminaires and the loss due to breakage when being cleaned. Three different types of indirect luminaires were chosen, a medium, a deep bowl with an interior deflector and opal diffusor, and a shallow bowl with metal deflectors. Three months after installation, foot-candle measurements were made and showed on the average for typical office space, 10.2; drafting rooms 18.7; corridors 0.9; President's office 11.3. Outlet spacings were 9 ft. 4 in. x 8 ft. 9 in., ceiling heights 10 ft. 10 in., suspension distances from the top of the deflector to the ceiling 2 ft. 6 in.

In another large office building considerable care was taken in the design of a trough lighting system for the arcade, in order to keep the reflectors from offending the eyes of persons in the gallery.[149] This arcade has a vaulted ceiling furnished in the Italian Renaissance period with medallions in shallow relief. Three hundred and fifty-four units were installed with 75-watt gas-filled tungsten clear lamps. The sections were wired to permit of three intensities of illumination, the short section in front of the columns being on a separate circuit to permit of low-intensity lighting after the evening traffic. The main office part of this building has a totally indirect system obtained by individual reflectors enclosed in luminous decorative bowls. Oversized diffusers utilize about 12 per cent of the light to illuminate the bowl and a dust cover, fastening into the inner top-supporting rim of the bowl serves to support the reflector and shut out dust. About 750 luminaires with 200 and 300-watt lamps were required.

Churches.—A special study of church requirements[150] led to the design of a lighting system which has caused considerable comment in the public press due to its somewhat spectacular character. In general it was desired to produce a sense of dimness in the auditorium corresponding to the theological idea, "a dim religious light" in contrast to a great brilliancy of illumination in the chancel and upon the altar. To get the gentle inassertive lighting in the main body of the church, suspended units were employed consisting of pyramidal opaque boxes with stained glass panels on the sides and with open bottoms. The unique character of the installation is found on the inside of these luminaires which

[149] *Light. Fix. and Lighting*, Nov., 1921, p. 18.

[150] *Elec. Rev.* (U. S.), Dec. 17, 1921, p. 919.

contain reflectors and a set of four color screens, blue, red, amber and green. In each unit are four 150-watt lamps one for each color screen, the whole concealed from view by a single sheet of opalescent glass. The colors are on independent electric circuits and can be separately dimmed so that any individual color-combination can be made to appear on the glass. Special outlets are provided for lighting the pews. The sanctuary and altar are brightly lighted by means of concealed units placed behind the imposts of the chancel arch. A single spot-light from a concealed source is directed downward upon the alter which can thus be flooded with white light when the chancel lights are out. Separate lighting is also provided for the gallery.

In another instance of church lighting, trough-reflectors containing 40 and 60-watt tungsten lamps have been employed.[151] The nave is lighted with 14 troughs concealed on the east side of the arched roof beams containing the clerestory windows. Thus the light comes from the same level as the windows. There is ample illumination at the pew heights and the congregation can look toward the chancel without discomfort. The latter is lighted by 6 troughs.

Theatres.—As in the case of motion picture theatres those for the spoken drama[152, 153] are also paying extra attention to their lighting systems. In the rehabilitation of one of the oldest theatres in London elaborate luminaires in keeping with the architectural scheme have been installed. The auditorium is illuminated from the ceiling by a central chandelier 8 ft. in diameter with provision for 30 lamps. It consists of a large upper corona surrounded by six three-light flambeau brackets and a lower corona completed by a panelled bowl, the whole being carried out in cast brass. The panels are glazed with heavy cut plate glass and the chandelier terminates in a lower cut glass bowl. Five smaller subsidiary luminaires of similar design together with numerous two-light flambeau brackets on the box and circle-fronts furnish additional light in this part of the theatre. Between the boxes are four large standards. Bowl pendants with silk cord suspensions, light the circles and are supplemented by three-light flambeau brackets.

[151] *Elec.*, Sept. 16, 1921, p. 361.
[152] *Elec. Rev.*, London, May 19, 1922, p. 715.
[153] *Elec.*, May 19, 1922, p. 596.

Considerable interest has been aroused among theatre-goers[154,155] by the practical application of colored lighting to produce colored stage scenes, using principles presented and demonstrated to this society a number of years ago.[156] By the use of red and blue lamps and the corresponding pigments in the stage settings and clothing of the actors, the scene is instantly changed to the wonder of the uninitiated onlookers. A device for throwing almost monochromatic colors on a theatrical stage[157] is made up with two octaves of keys like those on a piano. The upper octave controls colors while the lower gives twelve different degrees of white light. An intensely brilliant spectrum is formed by prisms and is projected by means of lenses, and the bands of color are manipulated through a series of shutters.

A novel method of illuminating the faces of singers[158] utilizes a hand flashlight enclosed in a metal compartment at the outer end of which is a polished metal reflector that catches the light, reflects and spreads it over the face. The whole is concealed in a bouquet of flowers held in the hand of the artist. By this means shadows, which have heretofore barred the use of the usual flashlight, are avoided and by shifting the bouquet various parts of the face and figure can be lighted.

Motion Picture Theatres.—The use of three or more different colors[159] on the same or separate circuits is becoming so customary in the newer moving-picture theatres as to be considered standard practice. Concealed sources are the rule,[160] supplemented in many cases by central chandeliers for architecturally decorative effects.

Novel luminaires adopted by the architect of an English motion-picture theatre[161] required considerable experimental and test work on the absorption of dyed fabrics and cathedral glass. Five-watt neon lamps in torch globe brackets have been extensively used in this theatre for decorative effects. The ceiling of a new moving picture theatre is divided into panels by five stained wood crossbeams.[162] The stage side of each one of these beams is

154 *Elec. Times*, Sept. 15, 1921, p. 220.

155 *Sci. Inven.*, Dec., 1921, p. 706.

156 "Color and Its Applications," Luckiesh, 1915.

157 *Elec. Rev.*, London, Jan. 27, 1922, pp. 128-129.

158 *Pop. Mech.*, Aug., 1921, p. 162.

159 *Mot. Pic. Wld.*, Nov. 19, 1921, p. 350.

160 *Mot. Pic. Wld.*, Jan. 28, 1922, pp. 375, 418.

161 *Elec. Rev.*, London, Jan. 20, 1922, p. 92.

162 *Mot. Pic. Wld.*, Nov. 19, 1921, p. 346.

hollow and contains a row of 85 white and colored lamps. This makes possible some very fine lighting effects while screening the sources from the audience. The proscenium arch is flooded by colored lights shining from within the orchestra pit.

Another new theatre[163] has aimed to have the most perfect lighting system of any theatre in the country. Every important light source has four color intensities, amber, white, red and blue with any combination of the four available and can be separately dimmed to darkness. The switchboard which is claimed to be the largest of its kind in the world is of the proselective type and controls the thirty different light centres in the building. The stage is illuminated from above by one hundred and ninety 150-watt lamps with a like number for foot-lights. In addition there are pockets in the walls for 48 spotlights. A battery of powerful lights hidden in the proscenium arch makes special color effects possible. The main auditorium is lighted by 8 large suspension chandeliers measuring 7 feet across, each provided with twelve 500-watt lamps, while bracket and banquet lamps are scattered throughout the theatre. The balcony is lighted by six smaller suspension lamps.

Motion Picture Studios.—Numerous improvements have been made in the lighting effects used in motion-picture projection.[164] By employing spotlighting, various details in pictures such as a vase of flowers, a piece of bric-a-brac, beautiful statuary, tapestries on the wall, etc., may be made to play a real artistic, colorful, living part. A new scheme has been worked out for door and window lighting, which dispenses with back lights. By coating the windows with an aluminum or silver paint, which acts as a reflecting surface for the light beams cast from the outside by the big searchlights, an appearance of light in the windows is produced without the use of a light back of the window. Brown paint simulates the appearance of drawn curtains. Instead of using blue filters to produce the impression of night scenes, all such scenes no matter how extensive are taken at night and the proper atmosphere is thus secured. One of the most valuable innovations introduced and perfected this year and one which marks an advanced step in illumination is a large overhead half-spherical dome-lamp by means of which indirect light from carbon arcs is supplied

[163] *Jour. Elec. and West. Ind.*, Dec. 15, 1921, p. 476.
[164] *Mov. Pic. Wld.*, Dec. 31, 1921, p. 1,142.

to the scenes below. The arcs are hidden from view by means of troughs. This results in a perfect diffusion of light which does not cast shadows. For the latter, additional spotlights are used. This indirect lighting is a very near approach to perfectly natural noon-sky light. Still another innovation is a long floor light which is similar to and serves the same purpose as stage footlights. A tin trough is used and contains carbon arcs equally spaced. Simply by the use of two large studio lights, successful motion pictures were made[165] of a ball given by the Motion Picture Theatre Owners of America. These lights have a 24-inch mirror.

Having passed from the experimental to the practical stage[166] two large so-called "actinic" searchlights are now working in motion-picture studios. They are said to be larger than anything employed in the navies of the world and may be used in the studios to produce diffused light by ceiling reflection in any volume required and over any desired area. They have segmented glass fronts, are mounted on wheeled carriages for the sake of portability, and have iris diaphragms to control the size of the emitted beam.

Factories.—A test has been made of the effect on factory output of different degrees of illumination.[167] The test was carried out in a factory-room devoted to semi-automatic buffing, and two illuminations 3.8 foot-candles and 11.4 foot-candles were employed. The machines in this room were of the revolving turret type. For the lower illumination, 300-watt clear lamps in bowl type porcelain-enamelled steel reflectors were used while the same outlets with 500-watt bowl enamelled lamps in R. L. M. standard reflectors were employed for the higher illumination. The lighting units were suspended approximately 14 feet above the floor. The power requirements were increased from 1.2 watt per sq. ft. of floor area to 2.01 watts in the two cases. Careful record of production was made for a period of five months, three months at the low and two months at the high. The following table shows the results:

[165] *Mot. Pic. Wld.*, Mar. 25, 1922, p. 413.
[166] *Pop. Mech.*, Aug., 1921, p. 200.
[167] *Gen. Elec. Rev.*, Dec., 1921, p. 1,023.

*	Moderate intensity per cent	High intensity per cent
Cost of lighting in per cent cost of labor	0.86	1.86
Cost of lighting in per cent factory cost of products	0.033	0.066
Average increase in production attributed to high intensity lighting		8.5
Increase in cost of lighting to increased value of production		0.4

*Cost of lighting includes cost of power at 1.5 cents per kw-hr., cost of lamps, 15 per cent depreciation on reflector equipment and 6 per cent on investment.

The general standard of lighting in factories and workshops in England is being improved as indicated by diagrams in the third report of the Departmental Committee on this subject.[168] For the various textile industries these diagrams show the percentages of workrooms which are lighted to various intensities and an appendix gives a table of foot-candle values to serve as a guide in practical requirements. They list for "fine work" three foot-candles and for "very fine work" five foot-candles, but these are not given as legal minima. The values specified in American codes are also summarized. The report suggests that the principal industries should be invited to assume partial responsibility for the fixing of legal values in the future by sharing in the researches on which they are based. The support of our society by the sustaining members is one way in which this result is being accomplished in this country. The British Home Office has issued[169] Welfare Pamphlet No. 7 which deals with the lighting of factories and workshops.

In revising the lighting conditions in a large factory,[170] a preliminary survey was made and followed by a test in a particular department of some seven different factory types of reflectors. The work in this department consisted of some very coarse, dark-colored weaving done by men standing up, one to a loom the table of which was 36 in. (0.9 m.) above the floor level. One hundred and 200-watt lamps were tried out and an average of 4½ foot-candles was taken as the requirement for satisfactory illumination. The result of this test led to the selection of an

[168] *Elec.*, July 7, 1922, p. 16.

[169] *Elec. Rev.*, Sept. 23, 1921, p. 422.

[170] *Elec. Wld.*, Dec. 31, 1921, p. 1,323.

R. L. M. dome reflector with 200-watt lamps spaced on 17-foot (5.1 m.) centers, 13 feet above the floor which gave 4.25 foot-candles.

The difficulties of lighting locations in which there is a great deal of dust[171] have been dealt with in previous reports. A solution seems to have been found in the case of a wood-working plant by the use of enclosed floodlights. A high illumination was desired on the working plane and on the feed rolls and cutting tools of the various machines doing exact or particular work. Three sizes of flood-lamps, 250, 500 and 1,000-watt were put in three types of reflectors, wide-angle, standard and concentrating. In addition to plain lenses, opalescent and diffusing prismatic glasses were employed. In most instances the units were placed so that the rays came to the plane at an angle of 20° to 30° from the horizontal, although an angle of 45° or even 60° was used in special cases. The units were kept clean, breakage and theft was reduced to a minimum and at the exact points needed there was plenty of light with an absence of glare.

By using two light sources[172] whose concentrated beams meet at an angle of 90° an effective illumination for punch or drill work has been accomplished. The two luminous pencils intersect at the surface to be drilled and form a rough cross whose intersection can be made to coincide with the punch mark.

When it comes to lighting a hydro-electric plant special consideration must be given to the wheel pit.[173] At one plant the ordinary 220-volt system was replaced in the pits by a 32-volt circuit in order to avoid danger due to damp or defective lamp cords. General illumination is provided by a few high-powered units with suitable reflectors, particular attention being given to the avoidance of shadows. Provision is made for an adequate use of portable lamps which are connected through a rugged type of heavily-braided water proof or vulcanized rubber cord to a portable distribution box which is set up wherever extensive repairs are necessary.

In a fruit cannery[174] it has been found desirable to have no shadows on the cutting tables in front of the girls who cut and sort fruit. In equipping a building which has a saw-tooth roof,

[171] *Elec. W'ld.*, Nov. 19, 1921, p. 1,227.
[172] *E. T. Z.*, Oct. 6, 1921, p. 1,144.
[173] *Elec. W'ld.*, Nov. 12, 1921, p. 978.
[174] *Jour. of Elec. and West. Ind.*, Aug. 15, 1921, p. 145.

200-watt lamps were used in R. L. M. one-piece reflectors spaced 18 feet apart and 14 feet above the floor. Three lights over each table are controlled by a single snap switch and in addition each set of six lights is grouped on one circuit in a panel-board, providing considerable flexibility in the system. At the turn-over tables the reflectors are on 10-foot centers mounted 9 feet above the tables, 14 ft. heights are used over the graders. Zinc white has been found[175] to absorb ultra-violet radiation almost completely and it has therefore been suggested that in all cases where it is possible for such radiation to be reflected into the eyes of operators, as in the case of arc welding, the walls and ceiling be painted with this material, known as "Chinese white" with a mat finish.

At first sight it might seem something of a task to light an X-ray examination room since the luminescent light of the willemite fluorescent screens has a continuous spectrum from 0.48 μ to 0.660 μ.[176] But by the use of a specially constructed color filter which transmits only the extreme red and the blue-violet the desired results may be obtained.

A novel effect was produced[177] at the banquet of the Fixture Convention in Milwaukee by the use of four searchlights, one in each corner of the ball-room, which at intervals concentrated their beams on a big ball studded with plane mirror surfaces. This ball was slowly rotated by a small motor and the light from the four projectors was broken into thousands of moving images providing a most interesting appearance, called by someone "The Dance of the Million Fire-flies."

Figures taken from a survey[178] of 1,500 middle class urban homes show that the average home has only 5.7 rooms with a lamp wattage of 863, an average of two convenient outlets, 1.6 portable lamps and two wall brackets.

LUMINAIRES

It is reported[179] in an old book published in 1810 that a globular lamp was patented in 1708 and displayed in 1709, described as follows: "A new kind of light composed of one entire glass of

[175] *Gen. Elec. Rev.*, Oct., 1921, p. 866.
[176] *Chem. Zentralbl.*, July 27, 1921, p. 203.
[177] *Elec. Merch.*, Feb., 1922, p. 61.
[178] *Elec. Wld.*, July 22, 1922, p. 193.
[179] *Elec. Times*, Dec. 22, 1921, p. 552.

a globular shape, with a lamp, which will give a clearer and more certain light from all parts thereof without any dark shadows." The book also states that the only change in street lighting in London between 1736, when 4,200 lamps were in use and 1808 was that of replacing the globe type by a bell form and attaching this in each case to the entrance of a big house. A further statement reads, "Several attempts to introduce strong reflectors have failed, as it has been uniformly found that they injure and confuse the sight."

The annual "lighting fixture" market held in Milwaukee last February gave an excellent opportunity to ascertain progress in luminaire design.[180] The new styles of luminaires are drifting into two classes, one made up of those designed primarily for illumination purposes, the other those patently for decoration. Of the first group the totally enclosing globe seems to be most in evidence. Squat or flattened shapes having a large downward projected area and a smaller horizontal area are popular. For store and office lighting the stalactite type is passing out of style. In the second class is to be noted the continued extensive use of round-bulb diffusing lamps especially on colonial candelabra. Silk-shaded ornamental table lamps maintain their popularity. Polished and brushed brass lead in finishes, with silver a close follower. More and more thought is being given to special finishes, to polychrome or enamelled and tinted parts and to silk cords, tassels, decorative chains and the like. The removable luminaire has not as yet made much headway in commercial use.

The research work of the Standardization Committee of the National Council of Lighting Fixture Manufacturers, to determine the maximum and minimum allowance for the several dimensions of the "heels" on blown glassware, in the 2.25 to 8-in. sizes, has been practically finished.[181] The heel is that portion of the globe or reflector which enters the holder or fitter. A complete set of master gauges is now available and permits the checking of four measurements at one time. If this standard is adopted by all manufacturers it will permit the production of a standard holder, for each size of glassware, which will take the holder screws in the proper position. A minimum inside

[180] *Jour. A. I. E. E.*, May, 1922, p. 385.

[181] *Elec. Rev.* (U. S.), Dec. 10, 1921, p. 892.

diameter will enable the dealer to tell what sized lamp can be used with any piece of glassware. The Committee has also been busy[182] on the standardization of screw threads which was made necessary by the fact that in the fixture trade there are about eighty-seven different sizes, threads, pitches, lengths and diameters of screws used. The details of this work have not yet been announced.

A dozen or fifteen types of luminaires cover nearly all types of lighting units used in commercial establishments and are sufficiently distinctive and standardized to be readily recognized.[183] For convenience in determining the size of lamp recommended for any size or diameter of reflector, tables have been arranged which give the various types of units and the sizes of both reflectors and lamps.

It is reported that 97 per cent of electrically lighted homes in this country[184] have luminaires of the direct lighting type while only 56 per cent of such luminaires have glassware and 31 per cent have no shades at all.

Reflectors.—In the alabaster-bowl type of luminaire used in England, a new design for indirect lighting[185] is provided with an upper reflector also of alabaster in the shape of an inverted cone. A foreign luminaire[186] is made in the form of a pear-shaped lamp bulb, of clear glass above with a diffusing bottom surface, and three conical-shaped reflecting surfaces one above the other, each tilted so that light from the lamp in the interior will be reflected downward without being intercepted by the next lower reflecting surface. Three sizes are made to take care of lamps from 60 to 150-watts, from 150 to 300-watts and from 500 to 2,000-watts. An American luminaire[187] also uses three reflectors but they are inverted cones and throw the light upward. A white metal husk surrounds the light socket and supports three diffusing louvres and a glass diffusing bowl. This unit is used for totally indirect lighting. A reflector lamp of mushroom shape has been brought out[188] fitted with a milk-glass shade for reflecting down-

[182] *Elec. Rec.*, Feb., 1922, p. 90.
[183] *Elec. Rec.*, Jan., 1922, p. 32.
[184] *Light Fix. and Lt.*, Nov., 1921, p. 14.
[185] *Ill. Eng.*, Nov., 1921, p. 226.
[186] *L. u. L.*, Nov. 3, 1921, p. 539.
[187] *Elec. Rec.*, Sept., 1921, p. 164.
[188] *Elec. Rec.*, Aug., 1921, p. 98.

ward rays which would otherwise be thrown on the ceiling. The shade is detachable. A mirror type of reflector[189] has been developed in Germany which it is claimed permits of great concentration of light and hence may be used for high suspension, thereby, avoiding glare. It is made in the form of a spherical cap adapted for show-window lighting; in the form of a deep reflector whose rays converge at a point in the plane of the rim of the unit, and then diverge, the angle of emergency and degree of concentration depending on the position of the lamp filament; and in a third form which is a combination of the other two. The mirror surfaces vary in diameter from 15 to 62 cm. and for projectors may reach 1.1 m.

Where the object is merely to protect the eyes from a light source very fanciful shields have been brought out in England in a variety of shapes, a most effective being the bird form.[190] Models of birds are made from cork with hand-painted wings. They are attached to the lamp-holder by a counter-balanced wire fitting. Numerous shields of this character but different in form have been produced in this country.

Luminaires.—A new luminaire which is somewhat different from the ordinary type provides an individual semi-translucent glass shade for each lamp.[191] These lamps are shaped like conch shells and are entirely open above. The unit may be made up with two, three or more of these shades and the general design made to harmonize with other furnishings.

An English luminaire for gas lighting is made on the plan of an old-fashioned yard-arm balance.[192] The tube from the ceiling rosette supports a swinging cross-arm which carries the lamp at one end and an adjustable weight on the other. In this way the height of the lamp can be fixed at any point within a considerable distance. In the old days of the coal oil lamp[193] arrangements were provided either in the way of chains or sliding tubes whereby it could be lowered for cleaning and filling and then raised to its normal position. This equipment is almost duplicated in a pendant luminaire which has pendant holders sliding

[189] *Elek. u. Masch.*, Dec. 4, 1921, p. 600.
[190] *Elec. Rev.*, (L.), Feb. 17, 1922, p. 222.
[191] *Elec. Rec.*, Mar., 1922, p. 175.
[192] *Gas Jour.*, Apr. 5, 1922, p. 24.
[193] *Elec.*, Sept. 2, 1921, p. 301.

over tubular guides giving an adjustment from 1 to 18 inches, and more if special sizes are desired. It can be made to accord with period designs, is very light and can be obtained in a number of finishes. Suspension chains made of crystal beads[194] are employed in an imported hand-painted inverted-bowl luminaire. The glass canopies and socket covers are painted to match the bowls.

Portables.—For taxing purposes[195] the term "portable" as used in connection with luminaires has been given an official definition as follows: "Portable lighting fixtures and portable lamps shall be deemed to include all lighting devices adapted for interior illumination and not designed to be affixed permanently in one location and all articles commonly or commercially known as such irrespective of the illumination used."

As in the past numerous unusual individualized ideas[196] have been expressed in portable and table lamps. Among these may be mentioned one representing a candle standing in an oriental slipper; another is in the form of an oval picture frame with the lamp socket attached to the top; a third is a combination lamp and incense burner with ash tray and match box attached; another of porcelain[197] is in the form of a ballet girl. Variety is given to a portable lamp of the type used to hang at any convenient point of a bed or chair by making the support in the form of a braided belt and adding a tassel.[198] It is made on the principle of a balance, a weight at one end counteracting the weight of the lamp and holder at the other. The braids, shades, shields and tassels are made in a number of designs, colors, and material. A very simple device[199] for the same purpose uses a wire fixed like a spring clamp. A unique table lamp made of ornamental cardboard can be folded[200] flat and mailed in an envelope. The shade is painted and semi-transparent and can be shaped into circular form by means of small tongues which fit in special grooves. An extra heavy base is provided and a holder to receive the socket of an incandescent electric lamp.

[194] *Elec. Merch.*, Dec., 1921, p. 332.
[195] *Light Fix. and Lt.*, Feb., 1922, p. 20.
[196] *Elec. Rec.*, Mar., 1922, p. 175.
[197] *Elec. Rec.*, Jan., 1922, p. 24.
[198] *Elec. Merch.*, Dec., 1921, p. 333.
[199] *Elec. Rec.*, Nov., 1921, p. 326.
[200] *Pop. Mech.*, Aug., 1922, p. 210.

Attachments for converting vases into portable lamps have been numerous but most if not all have provided for direct lighting only.[201] A new arrangement has fittings made in several different styles one of which is a three-light combination comprising a central indirect light and two adjustable side lights, separately controlled. A modification of this is a cluster fitted for direct lighting. Silk shade holders are available which permit the side lights to be turned upwards and close to the support enabling a small shade to be used with the vase. By the addition of a wire-frame top any type of shade may be used.

Luminaires for Special Purposes.—An ancient Cuban cathedral has been fitted with an electric chandelier.[202] Hanging from the center on a chain 85 feet long it consists of a cast brass band 54 inches in diameter supported by ten heavy braces reinforced with decorative metal strips. Thirty-five 8-inch ornamental glass urns for 100-watt lamps are suspended from the cast band and braces. The general design is open, of Romanesque detail and decorative.

One of the latest developments in fittings for show-window[203] lighting has a specially designed prismatic-glass reflector which is not affected by heat from the lamp and is provided with an inside color globe whose color is in the glass itself and is claimed not to fade. The use of these globes also tends to eliminate glare effects. Part of the reflector is made up with vertical screen-section prisms which are refracting instead of reflecting in their action. This section has a wide angle of utilization.

Lamps for hospital use[204] of the turn-down variety are quite common but most of them have only two or at most four possible intensities. A recent addition to this class is a boudoir lamp which has six degrees of intensity and may be used for lamps up to the 40-watt size. A special luminaire has been designed for use in gymnasiums, play rooms, loading sheds, etc.,[205] to protect the lamp from shocks and it is said to have successfully withstood a direct pressure of 200 pounds. It is provided with a porcelain enamelled reflector.

[201] *Elec. Rec.*, Apr., 1922, p. 249.
[202] *Elec. Rev.* (U. S.), Aug. 13, 1921, p. 252.
[203] *Cen. Stat.*, Aug., 1921, p. 26.
[204] *Elec. Rec.*, Mar., 1922, p. 175.
[205] *Elec. Rec.*, June, 1922, p. 413.

An English unit for lighting billboards[206] (boardings) consists of a sheet-copper trough with silvered glass reflectors which give a concentrated flat beam. The mouth of the trough has across its length louvres of diffusing glass and metal. The vertical surface of the board is evenly illuminated and the lateral distribution is sufficient to permit of 10-foot spacings. Each unit takes two 250-watt projector-type tungsten lamps.

An equipment designed especially for portable portrait photography[207] has a battery of five 400-watt lamps arranged in two banks which may be used separately. Special reflectors add to the available intensity and a diffusing screen is also provided. The development of special fittings for use in dentistry has proceeded to a considerable extent in Germany. These comprise adjustable luminaires for general illumination,[208] and numerous reflector units for individual classes of work.

The satisfactory and efficient use of the incandescent lamp in projection work requires such modification in the ordinary housings that complete equipment for this special purpose has been worked out.[209] A 2.5-inch lens, known in the trade as No. 2 is used instead of the No. 1 (1.5-inch) and doubles the light which would otherwise be thrown on the screen. Spare lamps are mounted in removable sockets and a pre-focusing arrangement, known as a lamp setter has been worked out so that when the lamp, once arranged in the socket, is inserted in the lamp housing the lamp filament will be in the proper optical position.

Residential.—For a time the dome design for central luminaires in dining rooms[210] seemed to go out of style, but it is returning although in a slightly different form. The effect is produced with the candelabra type of unit by using a cylindrical cloth, metal or fringe shade which serves to conceal the bare lamps and at the same time permit some lateral as well as upward diffusion.

Highway.—Continual progress is being made in the production of luminaires for highway and street lighting.[211, 212] A new unit is

[206] *Elec.*, June 2, 1922, p. 661.
[207] *Pop. Mech.*, May, 1922, p. 675.
[208] *Helios*, Jan. 29, 1922, p. 54.
[209] Report of Lamp Com., N. E. L. A., May, 1922.
[210] *Lighting Fix. and Lt.*, Nov., 1921, p. 10.
[211] *Elec. Rev.* (U. S.), Dec. 10, 1921, p. 874.
[212] *Elec. Jour.*, May, 1922, p. 194.

arranged for suspension from a series of interchanging fixtures to be fastened to brackets, mast irons or span wires as conditions may require. The reflector is made of a porcelain enamelled steel, white on the interior and bottle-green on the exterior. Its shape is parabolic and it is so arranged with respect to a pair of refractor prism plates that all of the light is thrown on a long stretch of road without loss in the fields on either side. Practically every ray of light from the lamp is deviated in the desired direction parallel to the roadway. To cut off glare from drivers, the edge of the reflector is shaped so that light in a line parallel to the direction of travel is cut off through an angle of 14° below the horizontal. Another[213] street lighting unit has a panelled globe in which upper and lower parabolic reflectors distribute a flood of light on the street with a small amount upward to light the fronts of adjacent buildings. In addition a portion of the light above is redirected by an opal glass band around the upper hemisphere of the lamp or by a band of enamel on the lamp itself. The maximum light is emitted at approximately 20° below the horizontal. Post or pendant forms are available.

The mortality of lighting standards used for traffic control on "Safety Islands" is so great that considerable attention has been given to methods of prolonging the life of such traffic aids. A fixture which is claimed to combine safety with visibility has a rectangular column[214] 9 feet high and illuminated from the inside from top to base. It is mounted on a ball and socket support which permits the whole column to swing when struck, in the direction of the blow. A heavy spring restores it to an upright position.

Materials.—A new material for lamp shades used to replace art glass[215] is said to be practically unbreakable weighs only about one-tenth as much as glass and may be obtained in any special color.

In order to save the weight and expense of carved alabaster,[216] bowls are made of moulded plaster rendered translucent by a special process. The casts are re-enforced with fabric and this enables any color or a "marble effect" to be obtained. The appearance of the bowl when not illuminated is that of pure white

[213] *Natl. Electragist*, May, 1922, p. 18.
[214] *Elec. Rev.* (U. S.), Aug. 6, 1921, p. 231.
[215] *Elec. Rev.*, Jan., 1922, p. 64.
[216] *Elec. Rev.*, London, Nov. 11, 1921, p. 655.

marble or alabaster. It is claimed that the brilliancy of a silvered plate-glass mirror is obtained in reflectors made from moulded crystal glass,[217] which has been annealed, chemically cleaned, treated to a hot process of silvering and finished with a gutta-percha paint, impervious to dust and moisture. These reflectors are being made in sizes from 3 inches in diameter for flashlights to 18 inches for locomotive headlights.

Accessories.—A new locking device to protect incandescent lamps[218] consists of two collars, one of which screws into the other. A ratchet fixed upon the inside of the outer collar engages, when the latter is turned in a right hand direction, with shoulders running across the thread of the inner collar. The parts screw together easily in the opposite direction. In fitting the lock, the lampholder is inserted into the inner collar with the outer part screwed home, and the lamp is put in. Then the outer collar is screwed down until it lightly rests upon the top of the lamp. The latter must be broken to be removed. The lock is arranged for the bayonet type of base. A special device for locking lamps on shipboard employs a ring containing channel slots and a locking screw set in obliquely.[219] The screw is slackened back until the lamp is in place, the ring is then rotated a trifle to bring the screw opposite to one of the slots with which it engages when screwed home. The ring is further provided with split threads so that it will fit on any lamp holder. In Germany[220, 221] the mounting price of metal filament lamps has stimulated the production of locking devices to prevent their unauthorized removal from sockets.

A new shade holder is fitted with many steel points on the holder nipple, the fastening operation being effected by turning the cover which has no thread.[222] The points which previously were pressed lightly against the holder are moved with it and the holder is screwed upwards on the nipple thus pressing the points firmly into the cover. The steady increase in the size of globes due to the high-wattage lamps now in use has raised the

[217] *Pop. Mech.*, July, 1922, p. 112.
[218] *Elec. Rev.* (L), June 23, 1922, p. 899.
[219] *Elec. Rev.*, London, Mar. 3, 1922, p. 322.
[220] *Elek. Anz.*, Mar. 7, 1922, p. 294.
[221] *Elek. Anz.*, Nov., 1921, p. 1,325.
[222] *Helios*, Nov. 6, 1921, p. 3,098.

problem of holding these large globes in the fittings.[223] Screws are no longer adequate for safety and a solution is found in the growing use of that class of holders employing flexible metal strips or fingers which when slipped into the neck of the globe may be pulled outward by means of adjustable screws and will permit of wide variations in tension without losing their grip.

To make available the property of ultra-violet light to accelerate fading of dyes or pigments,[224] a special equipment has been designed for testing purposes. A cabinet is provided which contains a mercury vapor lamp and space to put samples of the colored articles to be tested. A portion of the sample is screened from the action of the arc.

There is growing use in this country of lever switches of the toggle and tumbler type.[225] In contrast to foreign practice an instaneous make-and-break arrangement has been substituted for the slow action movements found abroad. To avoid the trouble of having to screw a plug into the old type of screw socket[226] a new attachment has four rounded threaded strips which, when the plug is pushed into the socket automatically expand, and when pulled out contract.

The use of remote controls for gas lighting is not unusual and it is used somewhat in electric lighting. A switch for this purpose[227] has a symmetrical magnetic system which turns a contact disc. It is employed not only for turning the lights on and off but also for connecting lights in series, and can be adjusted for different voltages by merely shifting a collar on a resistance rod.

For the automatic lighting and extinguishing of marine and aerial lighthouses[228] a new light valve makes use of a volatile liquid contained in two connected glass bulbs, one of these is blackened and even in comparatively weak daylight will heat up enough to cause a head of liquid to develop and some of it to flow over into the other bulb, thereby tilting the carrier which is free to rock and is connected by levers to the gas valve.

223 *Elec. Rev.* (U. S.), Dec. 10, 1921, p. 897.
224 *Cen. Sta.*, Apr., 1922, p. [illegible]
225 *Elec. Rec.*, Dec., 1921, p. 416.
226 *Elec. Merch.*, Apr., 1922, p. 98.
227 *Helios*, June 26, 1921, p. [illegible]
228 *Ill. Eng.*, Feb., 1922, p. [illegible]

The use of the electric spark to ignite the gas in burners is common practice but a foreign invention utilizes the gas pressure-wave principle to control electric circuits.[229] The gas pressure actuates a membrane connected through levers to a toothed wheel which in turn controls the position of a tube containing mercury. In the horizontal position of the tube the circuit is closed and when the tube is tilted the circuit is broken. The device is adapted to street lighting circuits where it is desired to turn off all or certain lights at a particular time.

Tests.—Experiments have been made in Germany[230] on the materials used in making globes, reflectors, and shades for lighting purposes. The tests included the effect of heating to 150° C. for two minutes in an oil bath and then a one minute cooling in a water bath at 10° C. The transmission of various kinds of glass was determined and showed for simple lamp glass of 1.6 to 2.2 mm. thickness 90 per cent; for ornamental glass 3 to 6 mm. thickness 56 to 75 per cent; for diagonal rippled glass 5.6 to 5.9 mm. thickness 67 per cent; for cathedral glass 3 to 3.7 mm. thickness 90 per cent. Tests were also made on impregnated paper tubes used as shades for gas lighting.

When the ordinary high wattage lamps first came into general[231] use a great deal of attention was paid to the ventilation of enclosing globes and fixtures. But present practice is in the direction of non-ventilated units because of the protection from dust and the possibility of more attractive design. Tests on a 200-watt unit having a metal housing for the socket at the top, a large, broadly flaring glass bowl, and a metal-bottom plate were made under different conditions of ventilation to determine exactly what effect ventilation had upon the operating temperature of the lamp and the lead-in wiring. The unit was made and intended for use with no ventilating holes. Five tests were made; non-ventilated; ventilated by holes in the top cap and in the bottom plate; ventilated by holes in the top cap only; same, but with the bottom plate removed; ventilated by holes in the tube and bottom plate. The results showed conclusively that the lamp bulb temperatures were not unduly high and were reduced only about 6.4°

[229] *E. T. Z.*, Apr. 6, 1922, p. 465.
[230] *L. u. L.*, Aug. 25, 1921, p. 394.
[231] *Elec. Wld.*, Feb. 25, 1922, p. 387.

even with maximum ventilation. However, ventilation in every case raised the temperature of the wire just above the socket and the more ventilation the hotter the wire. It was concluded that this result was due to hot currents of air rising from the interior of the fixture.

PHOTOMETRY

During the eclipse of the moon last October atmospheric conditions were such at Strasburg as to permit photometric measurements[232] of the illumination of the moon's surface, and a curve was obtained of the illumination at the interior of the umbra and penumbra as a function of the distance from the axis of the cone.

It is interesting to note that during the war the Physikalische Technische Reichsanstalt standardized on the average about five Hefner lamps per year, which number increased to fifteen in 1919 and reached the pre-war normalcy of fifty-five in 1920.[233] In that year sixteen carbon lamps were measured for use as photometric standards, and one hundred and eighty-three metal filament lamps for the same purpose. Sixty-nine of the one hundred and ninety-nine lamps were standardized for mean spherical candlepower. A number of 6 volts (up to 5 Hefner candle) lamps used in portable photometers were found to be unsatisfactory in their constancy of luminous intensity.

Apparatus—A modification of the small portable type of illuminometer has been developed in England.[234] Like an instrument brought out in this country some years ago, this meter has a rectangular box with a translucent top surface illuminated to various degrees of intensity on the inside by a small electric lamp placed at one end. This top is covered by a sliding plate, opaque and having a circular opening fitted with a Bunsen disk. The outer ring of the latter has an opaque albido surface, the central circle being translucent and receiving light from the illluminated screen just mentioned. By moving the sliding cover a position can be found in which the inner circle of the Bunsen disc tends to disappear when the foot-candle illumination may be read from the scale

[232] *C. R.*, Oct. 24, 1921, p. 706.
[233] *L. u. L.*, Oct. 20, 1921, p. 510.
[234] *Ill. Eng.*, Dec., 1921, p. 249.

attached to the instrument. The stock pattern has a range from 0.5 to 20 foot-candles, but special scales may be obtained for extra ranges.

A new variable rotating sectored disc[235] has a stroboscopic method of reading the angular opening while the disc is in motion. The disc has two sector openings so that two adjacent fields are presented to view and as the sectors are shifted one field increases while the other decreases in brightness. The reading device is different from the stroboscopic arrangement on the Brodhun rotating sector.

When equality of brightness is obtained in spectrophotometric measurements by the method of slit-width alteration, errors are introduced due, among other causes, to the impurity of the spectrum. This has been obviated[236] for instruments of the Vierordt double slit type by the use of a pendulum of short period operated by an electro-magnet. It has a bob in the form of a heavy frame of brass containing two rectangular openings, one above the other, the widths of the openings being adjustable like the photometer slits. Equality of brightness is then obtained by altering the width of one or the other of these openings. The electro-magnetic arrangement gives considerable amplitude and the equipment is free from the need of a motor. It has, however, the objection of all slit-movement systems that a given change in slit-width does not produce the same change in transmission for all widths of slit. It may be noticed that this arrangement is really a pendulum sector of the type described in a paper given before the American Optical Society at the Chicago Meeting in 1921.

Methods.—A rod moved back and forth in front of a bright background perpendicular to the line of sight will appear to move in a straight line only if the brilliancy for both eyes is the same. If the field for one eye is made different by holding in the light path a smoked or colored absorption glass, then the rod will appear to move in a circle on the left or right. This phenomenon is explained by the fact that between the stimulus and the sensation at the eye a time interval occurs which with decrease of brilliancy is always larger. This constitutes what has been desig-

235 *Jour. of Frank. Inst.*, May, 1922, p. 641.

236 *Phil. Mag.*, Apr. 1922 p. 662.

nated a "stereo-effect" which has been adapted[237] to isochromatic and heterochromatic photometry. It is assumed that two light sources, isochromatic or heterochromatic can be said to be equally bright if the time between the stimulus and the sensation is accurately equal, and the moving rod is used as an indicator as previously described.

A method of measuring colors has been devised[238] which consists essentially in the spectrophotometry of adjacent patches of the spectrum each patch of a width fixed by the hue scale the number of patches being dictated by the kind of color and degree of accuracy used. To make such measurements it is proposed to use special slits with movable jaws to facilitate the selection of adjacent spectral patches.

Computations.—At various times in the past nomographic scales or alignment charts have been worked out for shortening illumination computations. This type of scale contains a series of parallel vertical or horizontal straight lines so divided and spaced that straight lines drawn across them will show, at the intersections, the desired result. This idea has been extended[239] to cover such photometric computations as candlepower on an ordinary photometer bench, various characteristics of incandescent lamps at different voltages and various candlepower calculations. Several methods of calculation for determining illumination in rooms have appeared. One[240] considers the joint effect of two groups of light sources and gives graphical constructions for obtaining the mean illumination and also for the diffused light. Another[241] involves the use of specially prepared co-ordinate paper and includes the calculation of illumination by the point-by-point method, average illumination for a certain area by the flux-of-light method, the design of reflectors and the calculation of street illumination.

Most illumination formulae have been worked out for the purpose of determining conditions in the horizontal plane.[242] Methods have been given for vertical surfaces but as none seemed to be satisfactory for all conditions a new set has been given which

[237] *Z. f. Instr.*, Feb., 1922, p. 56.
[238] *Jour. Opt. Soc. of Am.*, Nov., 1921, p. 469.
[239] *E. T. Z.*, Jan. 19, 1922, p. 71.
[240] *Elek. u Masch.*, Sept. 4, 1921, p. 417.
[241] *Elec. Rev.*, Feb., 1922, p. 95.
[242] *Elec. Rev.* (U. S.), Dec. 10, 1921, p. 881.

is based on the "point-by-point" method and is claimed to be "truly general in nature and of practical service in designing the lighting installations for roundhouses, erecting shops, paper-mills, billboards, etc." Thus the illumination at a point on a vertical surface is given by the equation

$$E_v = \frac{IV}{(H^2 + V^2 + L^2)^{3/2}}$$

where I is the candlepower in the direction of the point considered, V is the perpendicular distance from the source to the wall, H is the vertical height from the source to a horizontal plane passing through the point and L is the distance in the horizontal plane from the point to the intersection of a plane through the source and perpendicular to the vertical surface containing the point.

PHYSICS

Light is such an important factor in human experience that it is quite natural for its effects to be made the subject of numerous investigations. It will be evident that the past year has seen little interruption in this phase of activity as illustrated by the number of results referred to in the section "Action of Light."

Light Sources.—It has been found that a continuous spectrum identical with the fluorescent spectrum is emitted from mercury[243] in a discharge tube in addition to the ordinary line spectrum, only when the temperature of the vapor is above 120° C. and below 300° to 400° depending on the pressure; when the pressure is above 1 mm.; when the current density is low and of the order of 10^{-4} amperes per cm.^{2} or less; when very little air or other contaminating gas is present. Ionization is not necessary for the emission of this continuous spectrum. An apparatus which is said to produce[244] a continuous ultra-violet spectrum out to 0.205 μ is a modification of an older type employing high frequency oscillations and a spark gap under water. The present form uses tungsten electrodes 3.5 mm. in diameter in a pyrex glass bulb about 500 cc. capacity having an inserted tube fitted with a quartz window. The spark gap is about 1 cm. from the window, and water flows into and out of the bulb through two openings. An

[243] *Astrophys. Jour.*, May, 1922, p. 329.
[244] *Jour. Frank. Inst.*, July, 1922, p. 83.

X-ray transformer using 15 amperes and 110 volts on the primary with a mercury interrupter and two Leydon jars for capacity furnishes the source of the discharge. A zinc spark gap upon which a blast of air is directed is placed in series with the tungsten gap. Using 1.6 kw. in the transformer the tungsten electrodes disintegrated very slowly and the spark length had rarely to be adjusted during a complete set of observations.

Ultra-violet radiation has been utilized to study the fluorescence of gems.[245] A necklace of Indian pearls was found to fluorescence with a bluish color, while Japanese cultured pearls gave a mustard green light. Though it has been known for some time that diamonds were capable of fluorescing under ultra-violet radiation, it has been found that gems which appear similar under ordinary daylight fluoresce in entirely different colors. River-bed diamonds appeared a dark brown, a Brazil diamond gave a bright blue and another from an unknown source, a yellow fluorescence. Experimental work on chemi-luminescence[246] and photo-luminescence of silicium compounds has lead to the following conclusions, among others: previously described chemi-luminescence by one oxidation of unsaturated silicium compounds is restricted to compounds of pure silicon; the intensity of luminescence is greatest for the yellow luminous preparations; the color of the light emitted by a reaction changes with increased concentration of silicon hydroxide from green, through yellow to red; at lower temperatures the oxides of the same quantities result in greater light output; the spectrum of luminescent light is a broad band from red to green, the strongly absorbed short-wave rays not being emitted; the color of the photo-luminescent light is the same as that of chemi-luminescence and undergoes the same changes in color and intensity with variations of concentration of silicon hydroxide. Silicon hydroxide showed a strong cathodo luminescence, whose color was the same as that of the chemi luminescence and showed the same changes.

Experiments on the electrical conductivity of crystals of calcite, fluorite and felspar,[247] all of which exhibit thermo luminescence when gently heated, showed that the electrical conductivity was increased when the thermo-luminescence was present. This

[245] *Ill. Eng.*, Dec., 1921, p. 237.
[246] *Zeit. f. Phys.*, May 3, 1922, p. 267.
[247] *Sci. Abs.*, *A.*, May 31, 1922, p. 432.

was in accord with what might be expected on the basis of the commonly accepted theory as to the mechanism of photo-luminescence. Luminescence is different not only in its variability with temperature and in its spectral distribution but also in showing marked fatigue effects and in varying with the previous heat treatment and with the mode of heat used. Some oxides when heated to a temperature lying within a definite and sometimes very narrow range, show a decided selectivity in a limited region of the spectrum, and this is ascribed to luminescence.[248] As an example the blue radiation from niobium oxide at 560° C. has been found to be about 85,000 times the corresponding radiation from a black body, the ratio decreasing with increasing temperature until it is 1.35 at 1,037° C. just before the oxide melts. The oxides of beryllium, magnesium, calcium, alum, silicon, and zinc also show a blue glow. Intensity temperature curves for the red, green and blue radiations from the oxides of samarium, gadolinium, gallium, niobium, erbium, cerium, praesodymium and neodymium, from 700° to 1,550° show that all except cerium emit a blue or green-blue glow, and all but niobium and neodymium have one or two red, green and blue outbursts above 1,000° C.

Photo-Electricity.—The photo-electric emission of a metal is affected not only by the gas it has absorbed but also by the gaseous layer adsorbed on it. The effect of the latter is to retard the electron emission. Experiments on a platinum strip exposed to various radiations from a mercury vapor lamp, the gas content of the foil being changed[249] by repeatedly heating it first to red then to white heat showed; the maximum wave-length capable of exciting electron emission increases from 0.26 μ to 0.30 μ for platinum when the adsorbed gas has been removed; as the absorbed gases are driven off the red limit shifts again to shorter wave-lengths, until it reaches a point near 0.27 μ; the decrease in intensity of the electronic emission for different wave-lengths is markedly effected by the gas content of the platinum, the result being most pronounced for the longer wave-lengths.

[248] *Phys. Rev.*, Apr., 1922, p. 300.
[249] *Ann. d. Phys.*, Apr. 12, 1922, p. 43.

For photo-electric cells made up with alkali metals in rare gases, the seeming non-proportionality of photo-electricity to light flux has been attributed to a rapid fatigue and recovery.[250] A slow change in the sensibility of the cells was noted, which was also attributed to fatigue phenomena. This fatigue is supposed to be due to adsorption of a positively charged layer of gas on the alkali metal. If this effect was eliminated the photo-electric effect was found to be proportional to the unit of luminous flux to within 0.1 per cent.

The effect of the temperature on the photo-sensibility of selenium has been given additional study[251] and a formula proposed to express the relationship. The results indicated that not more than 4 per cent of the "light effect" is attributed to heat produced by illumination. A change of color taking place at the same time as the change in resistance has been observed when warming crystals of selenium, produced by the sublima tional method. In contrast to selenium, molybdenum when exposed to green, blue or yellow light has been shown to have a higher resistance than when kept in the dark.[252] The action is apparently reversible since a small electric current has been detected from samples exposed to light.

Properties of Materials.—Additional work has been done on the effect of temperature on the transmission of glasses,[253] in this case for ultra-violet light. Twelve varieties of glass were studied at temperatures up to 45°, and in one case down to the temperature of liquid air and with radiation down to 0.225 μ. All exhibit a transmission limit below which the transmission for all shorter wave-lengths was practically zero. Increase of temperature in all gases raised this transmission limit toward the region of longer wave- lengths.

In the light of some new experiments it is apparently not safe to draw conclusions[254] as to the scattering of light by liquids from measurements on the absorption. In the case of water rendered dust free by the method of distillation in vacuum without ebulition and also of dust-free benzene, the following table gives the

[250] *Zeit. f. Phys.*, 1921, p. 18.
[251] *Phil. Mag.*, Sept., 1921, p. 461.
[252] *Pop. Mech.*, July, 1922, p. 8.
[253] *Chem. Abs.*, Apr. 20, 1922, p. 1,102.
[254] *Jour. Phys. Chem.*, May, 1922, p. 471.

extinction coefficient ϵ per cm. of water for light of three wave-lengths.

Wave-length	Ordinary distilled water	Optically empty water	Dust-free benzene
4,358 A	$\epsilon = 0.00087$	$\epsilon = 0.00012$	$\epsilon = 0.00056$
5,461	0.00072	0.00034	0.00024
5,780	0.00095	0.00064	0.00045

where ϵ is defined by the equation $\epsilon = -\frac{1}{d} \log_e \frac{I}{I_o}$, d being the length of the column of water in centimeters, and $\frac{I}{I_o}$ is the ratio of the intensity of light transmitted by water to that which is transmitted by air. Values for ordinary distilled water are also given.

Data on the absorption of light by sea water[255] is found in a report on experiments with a search light of sixty million reputed beam candlepower, using a 150-ampere arc in a 36-inch projector, which could be seen a distance of 62 miles in the air. The searchlight was placed in the bottom of a steel well 25 feet long having a plate glass window 40 inches in diameter. At a depth of 10 to 15 feet in the muddy waters of the New York navy yard there was total reflection of light attributed to the condition of the water. The window was seen to be surrounded by a luminescent sphere approximately 80 feet in diameter. This sphere was so bright that it acted like a fog to the observer's vision. Brilliancy of luminosity seemed to be about the same at all points of the sphere. In clear ocean water it was found that the beam could not be projected, and that a luminescent globe was again produced. This globe was visible for possibly a quarter of a mile and could be used to silhouette mines, anchors, cables, etc., against its white background. These results indicate the impracticability of projecting light through any great depth of water in such a manner as to aid divers or for other similar purposes. A new theory attributes the color of the sea to the molecular scattering of light in the water. This scattering[256] can be calculated and is found to be, in round numbers, one hundred and sixty times that in dust free air. This figure agrees with the value obtained experimentally.

[255] *Sci. Am.*, Nov., 1921, p. 57.
[256] *Proc. Roy. Soc. A.*, 1922, p. 64.

The light from a powerful lighthouse in France has been seen in clear weather[257] at a distance of 31 miles, while on exceptionally clear days it has been picked up at 41 miles. The transmission of the atmosphere corresponding to these two ranges has been computed to be 0.916 and 0.933 per kilometer of intervening air. A non-heat transmitting glass has been manufactured[258] which is claimed in 0.25 inch thickness, to transmit 42 per cent of visible radiation, eliminate all glare, and absorb 78 per cent of infra-red rays. It is suggested for use in containers of chemicals sensitive to light and heat and for windshields of automobiles where glare should be reduced.

The flame of the Hefner lamp or of the Pentane has been found to act like a turbid medium[259] in scattering incident light. Using the narrow beam from an arc lamp the intensity of the light scattered by the Hefner was increased by 300 per cent, as the angle between the incident beam and the direction of observation increased from 45° to 150°. The intensity of the scattered light was greater for short wave-lengths than for long ones, and the absorption, therefore, decreased with increased wave-lengths.

Action of Light.—A series of soda-lime glasses of the same composition, except that some contained Se, some CO oxide, and others no admixture, has been exposed[260] to the action of α, β, γ, rays from radium, X-rays and ultra-violet radiation. All containing Se, or CO oxide were colored brown by β-rays, the depth of coloration corresponding with the range of the β particles, being greatest at the surface and increasing with increase of Se or CO oxide content. As the radiation was prolonged the intensity increased to a maximum which depended on the percentage of coloring agent, and then remained constant. The pure soda-lime glass was only affected by α rays, being faintly colored on the surface. None of the glasses were effected by X-rays or γ rays or ultra-violet radiation. The coloration is regarded as due to the formation of colloidal particles within the glass, the presence of such particles being explained by the action of α- or β-rays on ions already present.

[257] *C. R.*, Jan. 30, 1922, p. 291.
[258] *Chem. Abs.*, Mar. 10, 1922, p. 804.
[259] *Kolloid Zeit.*, Mar., 1920, p. 99.
[260] *Jour. Soc. Glass. Tech.*, 1921, p. 1[illegible].

Experiments have also[261] been made on the effect of sunlight in decolorizing glass containing manganese, a phenomenon which was observed some years ago. The results confirmed those previously obtained, namely, that any glass that contains manganese shows a violet color if exposed to the sunlight for at least a month.

It has been found that in a number of instances[262] the presence of eosin, sometimes even in traces only, brings about a catalytic acceleration of the action of sunlight in biological and purely chemical systems.

Serum albumin and oval albumin which have been several times recrystallized have been found to become sensitive to intense light[263] either that from the sun or from a strong arc lamp, from which the infra-red and the ultra-violet rays have been removed. The serum albumin is many times more easily affected than the oval. The change has many of the characteristics of heat coagulation. It consists of two separate reactions: (1) denaturation—a primary chemical change; (2) flocculation—the precipitation of denatured particles. The primary reaction is accompanied by an increase of rotatory power and a decrease of surface tension.

The action of light of the visible spectrum on ozone has been investigated.[264] At room temperature ozonised oxygen containing 16 per cent (by weight) of ozone was deozonized by the action of intense light between the wave-lengths 0.40 μ and 0.80 μ. The use of light filters indicated that the effective regions of the spectrum lie between 0.76 and 0.67 μ and between 0.615 and 0.510 μ.

The vexed question of the nature of the chemical changes which take place in the haloids of silver when illuminated has been studied[265] with the aid of the microbalance. The results indicated that thin films of the chloride, bromide and iodide of silver lose weight when exposed in air to the sunlight. The original weight is almost completely restored by rehalogenation. The decomposition is greatly accelerated in a vacuum. Silver bromide decomposes into silver and bromine. The decomposi-

261 *L. u. L.*, Nov. 17, 1921, p. 555.

262 *Chem. Zentralbl.*, Jan. 25, 1922, p. 212.

263 *Proc. Roy. Soc. B.*, Mar. 1, 1922, p. 235.

264 *Jour. of Chem. Soc.*, Dec., 1921, p. 1,948.

265 *Jour. of Chem. Soc.*, Apr., 1922, p. 682.

tion of the haloids is accelerated by ozone but the presence of oxidizing agents is not essential. It is known that an exposure to ultra-violet light is sufficient to bring about changes in the properties of many gels.[266] Additional experiments on the effect of ultra-violet light show that silica gel impregnated with certain organic liquids will on such exposure give off certain gas products. Celluloid acts in a similar way.

Another explanation of the action of red and infra-red radiation[267] on the extinction of phosphorescence of various substances has been proposed.

When an alternating current is applied across a crystal of zinc sulphide by means of water electrodes in contact with two faces of the crystals, and one of these faces is exposed to the light,[268] it has been found that a current passes through the exterior circuit in the direction it would pass if the crystal were a source of current with the lighted face as the positive pole. The strength of the effect varies greatly with the crystal. The magnitude of the effect increases with the intensity of the light and the strength of the applied alternating field. The effect is selective, being strong in the blue, weak in the green, and absent in the yellow and red. The current strength is roughly proportional to the candlepower of the incident light when this exceeds a certain threshold value.

Using the method of isochromats a new value[269] of the constant c_2 in the Planck radiation formula has been obtained, namely 14,270.

PHYSIOLOGY

Theory.—A further discussion, which considers the retinal apparatus,[270] of the so called quantum theory of color vision has been presented. The basis of this theory is given in the following statements: the number of spectral quanta converted into electronic energy and thereby rendered capable of exciting vision is controlled by the light absorption and the bleaching of the visual purple (or a substance possessing a similar spectral curve); the

[266] *Jour. of Phys. Chem.*, Jan., 1922, p. [illegible]

[267] *C. R.*, Feb. 20, 1922, p. 55[illegible]

[268] *Zeit. Phys.*, 1922, p. 182.

[269] *Zeit. Phys.*, May 3, 1922, p. [illegible]

[270] *Proc. Roy. Soc. B.*, 1921, p. [illegible]

quanta, increasing in energy from the long to the short wave-lengths, stimulate two, three and four fibres of the cone according to their energy as shown by the color sensation curves. The simultaneous stimulation of two fibres is attended by the red sensation; of three fibres by the green, and of four fibres by the blue sensation. The unit of luminous stimulation is the nerve discharge of one fibre. No color sensation is associated with this stimulus. Another theory of vision[271] assumes that the light absorbed on the pigment of the retina liberates electrons whose velocity varies with the wave-length of the absorbed light and which are collected by the rods and cones and again conducted to the central organ. Various velocities of electrons liberated at the same time will in their path conduce to an ultimate mean velocity (phenomenon of color mixture).

A new theory of intermittent vision postulates three steps[272] in the process of the perception of flicker. The first step consists of a photo-chemical reversible reaction of such a nature that the equilibrium value under steady illumination is proportional to the logarithm of the stimulus. The second step consists in a conduction process, according to the Fourier diffusion law. The third step consists in a perception process in which the criterion for perception is that the time rate of change of the transmission reaction must exceed a certain constant critical value. The theory has been evolved on the basis of previous work and some additional experimental data. Formulas have been derived with which a complete family of low and high intensity critical frequency curves for abrupt transitions of illumination may be plotted. A study has been made[273] of critical frequency relations in scotopic vision as a part of a more complete study of "rod" vision. The subject specifically taken up was the effect on critical frequency of the *form factor* of the intermittent illumination. At low intensities, it was found that with blue light, critical speeds of disappearances of flicker became independent of the intensity but differed for each wave-length of the stimulus.

Ophthalmologists draw a clear line of demarcation between three factors of vision which they call the light sense, the form sense and the color sense respectively. New data have been

[271] *Phys. Ber.*, Apr. 1, 1922, p. 346.

[272] *Jour. Op. Soc. Am.*, June, 1922, p. 347.

[273] *Jour. Op. Soc. Am.*, May, 1922, p. 254.

given[274] bearing on the problems related to the separateness of the mechanisms underlying two of these factors, *i. e.*, those of the light sense and the color sense and which are explained in terms of the zone theory of vision. It was concluded that to arrive at a thorough understanding of the mechanism or theory of visual response, it is absolutely necessary to take into consideration the zonal structure of the mechanism involved. Based on the assumption that visual impressions are transmitted at each fiber of the optic nerve by a series of impulses whose effect depends only on the frequency, quantitative expressions for the effect of light and dark surroundings on vision have been derived[275] which for foveal vision, with empirically selected values of the coefficient for the relative effect of different parts of the field accord well with observations of difference threshold and of its "diffusion."

Visual Acuity.—The experiments on flies referred to elsewhere in this section of the report suggested experiments on foveal vision in the human eye. The method[276] included a control of the initial light adaptation, a record of the exact beginning of dark adaptation and an accurate means of measuring the threshold of the fovea after different intervals in the dark. The results showed that dark adaptation of the eye as measured by foveal vision proceeds at a very precipitate rate during the first few seconds, most of it takes place in the first 30 seconds, and that the process practically ceases after 10 minutes. On the assumption that the photochemical effect of the light is a linear function of the intensity it is shown that dark adaptation of the fovea itself follows the course of a bimolecular reaction. This is interpreted to mean that there are two photolytic products in the fovea; that they are disappearing because they are recombining to form anew the photosensitive substances of the fovea; and that the concentration of these products of photolysis in the sense cell must be increased by a definite fraction in order to produce a visual effect. Experiments[277] on the visibility function and threshold for color defectives indicate that an abnormal visibility function is not necessarily associated with color defect but that color defective

[274] *Jour. Op. Soc. Am.*, Jan., 1922, p. 1.
[275] *Jour. Exp. Psychol.*, Feb., 1922, p. 19.
[276] *Jour. Gen. Physiol.*, Nov. 20, 1921, p. 113.
[277] *Jour. Op. Soc. Am.*, June, 1922, p. 362.

vision does condition a perfectly definite modification of the visual function and that a theory of vision should interrelate brightness sense and color sense to an extent sufficient to account for this fact.

In the 1918 number of this Report[278] two values of the minimum radiation visually perceptible were reported, *i. e.*, 3.9×10^{-9} ergs per second and 1.25×10^{-9} ergs per second. Another investigation[279] of this quantity for both colored and white light, where a dark adaptation of 25 minutes was employed, gave mean values for seven observers of

3.85×10^{-7}	for $\lambda = 0.4\ \mu$
1.6×10^{-8}	0.5
3×10^{-9}	0.55
2.2×10^{-7}	0.65
2.5×10^{-5}	0.72

and for total radiation

$$3.8 \times 10^{-11}$$

Figures for the threshold value of the retinal illumination necessary to produce the sensation of vision with images of variable angular dimensions indicate[280] that up to an angle of vision of about 5 minutes for the cones and 10 minutes for the rods, the amount of illumination required rises rapidly with decrease of angle. From this it is deducted that with faintly illuminated objects the use of magnifying glasses at night may bring an object within the range of vision by increasing the size of the image. A threshold method of measuring retinal sensitivity has been proposed[281] by which a stimulus of very small and fixed extent is exposed for a very short measured time. Experiments showed that the product of the time of exposure by the area of the stimulus was constant on the average at the threshold.

After an examination of one hundred subjects comprising airplane pilots and officers and men of other branches of the government service it was concluded[282] that binocular parallax is the essential factor in depth perception and hence that for accurate judgment good binocular vision is necessary.

[278] TRANS. I. E. S., 13, 1918, p. 504.
[279] *Jour. Gen. Physiol.*, July 30, 1921, p. 743.
[280] *Zeit. Tech. Phys.*, 1921, p. 245.
[281] *Jour. Exp. Psychol.*, June, 1921, p. 175.
[282] *Am. Jour. Ophth.*, May, 1922, p. 343.

Speed of Vision.—In order to obtain a fundamental idea of the influence of different intensities of illumination upon the speed of vision and ultimately if possible to determine the exact relation existing between these two things, experiments have been made[283] with seven observers using apparatus especially constructed for this purpose. The results showed a rapid initial increase in the quickness of impression as the illumination was changed from 0 to approximately 18 foot-candles and a continued but smaller increase for higher illuminations up to 100 foot-candles, the limit of the apparatus. An investigation along similar lines had for its purpose to see what is the effect of light of different spectral character upon cognitive reaction time and what is the effect on this reaction time of different intensities of illumination.[284] The light sources used were diffused sun-light, a mercury vapor lamp and two gas-filled tungsten lamps of 200 and 300 watts rating respectively. It was concluded from the results that continuous spectral light produces a lag in cognitive reaction time in comparison with the line spectral light of mercury vapor; that a similar action occurs with tungsten light as compared to sunlight; that differences in reaction time in general vary directly with the amount of illumination; that the minimum illumination required for maximum visual efficiency in reaction time is between 10 and 20 foot-candles.

Eye Strain.—In order to prove that the sensibility of the eye depends not only on the intensity of illumination of the surface observed but also on the character of the distribution of the light source, experiments have been carried out[285] with three decidedly different types of luminaires, one an ordinary unit with enamelled metal reflector, one a table lamp with red silk shade and one a special type made with a luminous surrounding tube. The results appeared to confirm other experiments that to obtain the same eye sensitivity it was necessary in the case of the metal reflector which gave direct unshielded light to use a luminous unit 28 per cent higher than in the case of the other two which tend to suppress glare. Experiments made to find the effect of fatigue with red light in the white equation (the amount of pure spectral red,

[283] *Jour. A. I. E. E.*, Feb., 1922, p. 149.
[284] *Am. Jour. Psych.*, Jan., 1922, p. 97
[285] *E. T. Z.*, Dec. 15, 1921, p. 1,434.

green and violet required to match a simple white) yielded results[286] considered to be quite inconsistent with the three-sensation theory of vision.

An improvement[287] in the method of increasing visibility of distant objects by the elimination of reflected light, consists in the use of tourmaline in place of the usual Nicol prism. A very thin plate of tourmaline cemented as a semi-lens on to an ordinary pair of spectacles will produce the result. The tourmaline must be cut parallel to the vertical axis. If used when fishing the glare from the water is completely obliterated. Another use is in connection with the study of photo-micrographs where the intense illumination required makes objectionable reflection from the glass.

A report on "Accidents due to Eye Defects" by the Committee on Elimination of Waste in Industry, of the American Engineering Council states[288] that out of 2,906 garment workers only 743 had normal vision in both eyes. An examination of more than 10,000 employees of factories and commercial houses revealed 53 per cent with uncorrected faulty vision. Of 3,000 employed in a paper-box factory only 28 per cent were normal in vision. The first report of the Miners' Nystagmus Committee appointed by the British Medical Research Council gives among others the following conclusions:[289] The essential factor in the production of miners' nystagmus is deficient illumination. Other factors are of secondary importance only. The deficient illumination is due to the low illuminating power of the safety lamps generally used by coal miners, to the distance at which these lamps have to be placed from the objects looked at and the great absorption of light by the coal and the coal-dust covered surfaces. Workers at the coal face are more affected than other under ground workers. The Medical Research Council has appointed[290] a committee to study the action of light on the human body in health and disease.

Again reference should be made to a review and summary of progress in visual science in 1920[291] and also to a review[292] of the physiological action of light which contains a bibliography.

[286] *Proc. Roy. Soc., B.*, 1921, p. 232.
[287] *Nature*, Nov. 10, 1921, p. 337.
[288] *Jour. A. I. E. E.*, Feb., 1922, p. 151.
[289] *Ill. Eng.*, Mar., 1922, p. 97.
[290] *Nature*, Mar. 2, 1922, p. 274.
[291] *Am. Jour. Physiol. Op.*, Oct., 1921, p. 316.
[292] *Physiol. Rev.*, Apr., 1922, p. 277.

ILLUMINATING ENGINEERING

Daylight Saving.—Last year 75.5 per cent of the people in New York State enjoyed the benefits of daylight saving, but owing to the opposition in the agricultural districts this percentage was cut down[293] this year to 73. Two out of every three persons in New England, New York, New Jersey, Pennsylvania, Delaware and Maryland are observing daylight saving time. In Washington, D. C. Congress, having failed to establish daylight saving for the District, a voluntary daylight saving was attempted[294] by the government departments which were opened and closed an hour in advance of the regular time. This was found unsatisfactory, however, owing to the failure of the people to adjust their night life. In Kentucky a state daylight saving bill passed[295] the legislature and was put before the governor for signature, which prohibited all cities from adopting anything other than Central time except where the governor may issue a proclamation under which the entire State will adopt daylight saving.

A bill before the British Parliament provided[296, 297] that Summer Time shall come into operation each year "on the day following the last Saturday in March," and shall last until "the day following the first Saturday in October." This is in accordance with an agreement between the French, English, and Belgium governments to have their starting and ending times the same.

On the ground that daylight saving worked injury to the farmers the French Chamber of Deputies passed a bill which, while enacting[298] daylight saving for 1922 as usual provides for its elimination in 1923. A councillor of the city of Paris urged that city[299] to maintain daylight saving, declaring that its enforcement from March 15 to October 25, 1922, brought about a saving of 200,000 tons of coal, representing 100,000,000 francs.

Light Sources.—A diffused light of unknown origin is claimed[300] to be responsible for the ability of the human eye to see only a relatively small number of stars in the night sky. Its intensity is given

[293] *Elec. Wld.*, May 27, 1922, p. 1,091.
[294] *Elec. Wld.*, June 17, 1922, p. 1,211.
[295] *Moving Picture Wld.*, Apr. 1, 1922, p. 461
[296] *Elec. Rev.* (L.), June 30, 1922, p. 926.
[297] *Gas Jour.*, Feb. 15, 1922, p. 367
[298] *Elec. Wld.*, Mar. 25, 1922, p. 601.
[299] *Elec. Wld.*, Jan. 14, 1922, p. 101
[300] *Scientia*, Oct., 1921, p. 271.

as one five-hundred-millionth of sunlight and if it were not present it would be possible to see stars of the eighth magnitude or ten times as many as are now visible to the unaided eye. Improvements in the artificial daylight unit of the reflecting type developed in England have been made[301] in the direction of improving the efficiency. As a result of the study of a large number of pigments a light ultra-marine has been found which is more luminous and as satisfactory as the darker color previously used. The emerald-green has also been improved upon and a yellow pigment substituted for the vermilion previously used. Rough observations indicate that the quantity of light obtained has been approximately doubled by these changes. The types of these units at present on the market include two industrial shades of 30-inch and 18-inch diameter for 1,000 or 500-watt and for 300-watt lamps respectively. Two types of standard lamp are also being made each employing a 150-watt lamp, one a two-light fitting, the other a reading lamp while special units are being made for art galleries, studio and shop-window lighting and for the dental and medical professions.

In the living world are said[302] to be more than thirty groups of organisms producing light, and while it is impossible, due to lack of data at the present time to classify accurately and logically the various types of luminosity found in living things an attempt has been made in this direction. Among sixteen groups of luminous forms investigated for the purpose of demonstrating the luciferin-luciferase reaction, now generally accepted as the source of light in the fire-fly, it has been found in only four, fire-flies, Pholas, ostracods and Odontosyllis. In many groups this is attributed to the small amounts of these substances present in the luminous organisms, or to their instability. In the medusae and permatulids, despite a large amount of luminescent material, luciferin and luciferase have not been demonstrated. Luciferin of one form will not luminesce with luciferase of another form or vice-versa unless very closely related (Cypridina and Pyrocypris). All experiments emphasize the specificity of the light-producing substances of Cypridina.

[301] *Ill. Eng.*, Nov., 1921, p. 215.
[302] *Jour. of Gen. Physiol.*, Jan. 20, 1922, p. 285.

Continued studies of the light emitted by the Japanese ostracod, Cypridina Hilgendorfi, have shown[303, 304] that the decay curve of the luminescence assumes the form of a bimolecular reaction in which two reactants are present in equimolecular concentrations. There is a superficial resemblance between this decay curve and that of inorganic phosphoresence.

It is well known that the larvae of many aquatic animals respond to light but little is known[305] regarding the exact nature of these responses. Work done on certain tadpoles (Amaroncium) showed a fairly precise orientation. At first strongly photopositive they remained so for only a few moments and then became photonegative. Increase in illumination had no effect on resting specimens, but active negative specimens responded by changing the direction of motion. The responses to light were dependent on the time rate of change in illumination. More work on this subject[306] showed that for another kind of tadpole (Rana clamitans) for less than 0.3 candle meters illumination, there was no physiological effect regardless of the time of exposure. With effective illuminations below 20 candle meters the changes in the receptors proceeded according to the Bunsen-Roscoe law. Eyes are not necessary for the responses of tadpoles to light of the kind used in these experiments (tungsten electric lamps up to 40-watt size). Experiments[307] on the effect of ultra-violet radiation on sea-urchin eggs resulted for 5 to 15-minute exposures in a membrane-formation associated with cytolytic action. Eggs thus affected showed the usual increased susceptibility to the activating influences of hypertonic sea-water. Other experiments have also been made[308] on marine animals having a phototropism clearly positive, in order to determine whether they place themselves in the direction of the light rays or react to different degrees of illumination. Sunlight was used as a source. The results indicated that the movements were not such as to orient the animals in the direction of the rays, but irregularly, and so as to bring them into more strongly illuminated portions.

303 *Jour. Frank. Inst.*, Jan., 1922, p. 111.
304 *Jour. Gen. Physiol.*, May, 20, 1922, p. 517.
305 *Jour. of Exp. Zool.*, Oct. 5, 1921, p. 149.
306 *Jour. of Exp. Zool.*, Oct. 5, 1921, p. 215.
307 *Am. Jour. of Physiol.*, July 1, 1922, p. 258.
308 *C. R.*, Nov. 21, 1921, p. 1,026.

The effect of light on the movement of crawling flies (Drosophila melanogaster) has been investigated[309] and it was concluded that the effect is related to the intensity of the photic stimulus according to the Weber-Fechner law, and secondly that the race of flies known as *vestigial* is positively phototropic. Experiments to see whether insects are sensitive to ultra-violet light which is not perceptible to the human eye, indicated[310] in the case of certain flies a marked reaction to radiation which was not evident to human vision.

Two years ago reference was made in this report[311] to the regulatory action of the relative length of day and night in initiating or inhibiting the flowering and fruitage of plants. Additional work on this effect of day-length which has been named "photoperiodism," has been carried out[312] and it has been found that the duration of the daily illumination period not only influences the quantity of photosynthetic material formed but also may determine the use which the plant can make of this material. In general there is an optimal light period for maximum upward or apogeotropic elongation of the stem. Departure in day-length from the optimal for increase in stature causes loss of dominance of the apical bud, thus promoting various types of branching. Leaf-fall and entrance upon the rest period, also, result from exposure to a certain length of day which is unfavorable for stem growth. Formation of bulbs is induced by excessively long days while formation of tubers commonly results from excessively short days. In order to prevent fungus growths on plants a French botanist has been investigating[313] the effect of colored screens. He obtains the screen by spraying on the leaves, stalks, flowers and fruits of the plants to be studied a harmless colored solution. The results are not stated.

Photography.—As a result of experiments on the effect on a photographic plate of different spectral regions when exposed separately and mixed in such proportions as to produce the same change as would be obtained if they acted independently,

[309] *Sci.*, June 23, 1922, p. 678.
[310] *Sci.*, May 12, 1922, p. 519.
[311] TRANS. I. E. S., 15, 1920, p. 489.
[312] *Sci.*, June 2, 1922, p. 582.
[313] *Sci. Am. Wkly.*, Sept. 24, 1921, p. 223.

it was found[314] that over the spectral range used, radiations of different frequencies do not act independently in producing the photochemical changes, but probably as a total amount irrespective of any difference in quality. Comparing[315] a neon glow lamp with a tungsten lamp as safety light sources behind yellow filters for dark room illumination it was found that the neon is safer for bromide paper and non-color-sensitized plates and has the advantages of remaining almost cold, and having a longer life. Without a filter it is a very suitable illuminant for passages in the neighborhood of dark rooms.

Legislation.—A tentative industrial lighting code has been issued[316] by the State of Massachusetts with the object of permitting its experimental application by employers before it is made mandatory. A code is also under draft in the State of Washington.

The attorney general of the State of Washington has made a ruling[317] that street lights are not a necessity and must be discontinued when the city has gone beyond its legal limit of resources. As a result the streets of Winlock, Washington, were for a time in darkness when the lighting system was shut off. In the opinion[318] of the Idaho Public Utilities Commission the use of electric energy for lighting purposes is more important than its use for commercial purposes and if there is not enough energy for both, lighting customers must be served first.

Most of the more recent automobile headlight regulations have been based[319] on two main requirements given in tentative specifications drawn up under the co-operation of the Illuminating Engineering Society and the Society of Automotive Engineers. These are "that the light projected ahead of an automobile shall not exceed 2,400 cp. directly in front of the car at an elevation of 1° above the horizontal, through the head lamps, or any point above that, nor 800 cp. 1° above the horizontal and 4° to the left of the axis of the car;" and "that the light projected ahead of the car must be at least 4,800 cp. and preferably 10,000 some-

[314] *Proc. Royal Soc. A.*, Oct. [illegible], 1921, p. [illegible].
[315] *Phot. Ind.*, Mar. [illegible], 1922, p. 246.
[316] *Elec. Wld.*, May 13, 1922, p. 971.
[317] *Elec. Wld.*, Apr. 1, 1922, p. 650.
[318] *Elec. Wld.*, Jan. 28, 1922, p. [illegible].
[319] *Gen. Elec. Rev.*, Feb., 1922, p. [illegible].

where between the horizontal and 1° below the horizontal." Legislation embodying these requirements has been passed in states which cover 45 per cent of the total automobiles registered in the United States, and 40 per cent in Canada. The British Departmental Committee on Headlights and Vehicles has issued[320] its third interim report. The regulations proposed are two in number, *i. e.*, that the range of forward illumination shall not exceed 150 feet at any point more than 4 feet above the ground and that the front of any headlight, viewed from any point more than 4 feet above ground shall have a reasonably soft illumination throughout its whole surface, without blinding lines or points of light.

A Second Interim Report has been issued[321] by the British Departmental (Home Office) Committee on Lighting in Factories and Workshops. The first subject considered is that of the requirements for suitable lighting, which are listed under three headings, glare, shadow and constancy. Attention has been given to the lighting codes adopted in certain American States and to recommendations on industrial lighting of this Society and that of Germany. As a simple practical criterion of proper shading of a source the Committee suggests the inability to distinguish the incandescent filament, mantle or flame as such, when viewed through the shade. Sources at 100 feet or more from the observer are excluded from the above requirement. Under the second heading it is recommended that "adequate means shall be taken to prevent the formation of shadows which interfere with the safety or efficiency of any person employed." Under the third heading it is recommended that "No light sources which flicker or undergo abrupt changes in candlepower in such manner as to interfere with the safety or efficiency of any person employed shall be used for the illumination of factories or workshops." An appendix to the report gives extracts from various American codes.

As a sequence to the Batignolles tunnel disaster the Minister of Public Works has ordered[322] all railway companies in France to discontinue the use of gas for train lighting. For express trains

[320] *Ill. Eng.*, Nov., 1921, p. 209.
[321] *Ill. Eng.*, Oct., 1921, p. 192.
[322] *Gas Jour.*, Oct. 19, 1921, p. 249.

the change must be completed by Jan. 1, 1923, and for suburban trains by Jan. 1, 1924.

Societies.—For the purpose of promoting better lighting in Milwaukee, Wisconsin, various interests including illuminating engineers, contractors and dealers, manufacturers and jobbers, the local electric light-and-power company and the Chandelier Club have formed[323] an association. It proposes to disseminate knowledge of the latest developments in lighting among those connected with the electric industry, to educate business men and the public in the value and economy of good lighting in factories, offices and homes and to support the movement by demonstrations.

At the ninth "Jahrestagung" of the German Illuminating Engineering Society[324] at Frankfurt, factory lighting was the main subject of discussion. Among others, papers were presented on "the general requirements of factory lighting, both artificial and natural;" "Industrial inspection and factory lighting;" "Defining the position of the eye-physician and practical experiences of the Baden official industrial inspection."

The German "Kommission für Lichttechnik" has issued[325] another text, which covers the relation between various photometric units and quantities and definitions of terms used in connection with light sources and illumination.

General.—The Department of Education of New York City has started[326] a course in the Principles of Artificial Lighting which is given at two schools, twice a week in two-hour sessions. The course includes instruction in the various methods of illumination and in fundamental and visual acuity tests. Exhibits of light units are furnished and the merits of the various types discussed. Trips through manufacturing plants, to theaters, halls and institutions are conducted where the class is allowed to see and study installations of good lighting and its effects.

The Report of the British National Physical Laboratory for 1920 shows[327] that it has undertaken experiments on ships' navigation lamps, on miners' lamps and on motor car headlights. It

[323] *Elec. Wld.*, Dec. 10, 1921, p. 1,188.
[324] *L. T. Z.*, Dec. 22, 1921, p. 1,178.
[325] *L. T. Z.*, Mar. 23, 1922, p. 403.
[326] *Elec. Rev.*, Jan., 1922, p. 3.
[327] *Sci.*, Aug. 12, 1921, p. 125.

is assisting the Office of Works in connection with the lighting of government offices, museums and other buildings. Experiments have been made for the purpose of securing adequate illumination at the National Gallery, while avoiding direct sunlight and diminishing as far as possible glare and direct reflection of objects and people on the glass which covers the pictures. Measurements in the House of Commons showed that the illumination was very low, less on the average than the equivalent of 1 foot-candle.

A report from Missouri states that 20,523 farms in that state have modern lighting facilities.[328] There is a total of 8,006 isolated electric lighting plants, individually owned, installed on different farms, while 3,133 farms secure electric service from central stations and other outside sources; 9,384 farms are equipped with acetylene lighting plants.

The use of polarized light to increase vision by eliminating detrimental reflections, referred to in the section on physiology, has been applied to the examination of old oil paintings.[329] The entire area of the painting is illuminated by a projection system which contains a Nicol prism. The observer looks at the work of art through another Nicol prism and manipulates the prism until he finds a position in which superficial reflections are entirely suppressed. It is said that old dull pictures then become quite distinct the colors are intensified and details long lost to the naked eye appear in their original form.

BOOKS AND JOURNALS

At the end of last year[330, 331] the *Electric Review* was purchased by the owners of the *Electric World* and other publications and renamed "*The Electrical Review and Industrial Engineer,*" becoming a practical monthly magazine devoted to the operation and maintenance of electrical and mechanical systems in mills and factories. Long one of the mediums in which articles on illumination have appeared frequently it would seem that the change will end this sphere of its influence.

The Journal of the American Optical Society has been enlarged to include a section on scientific instruments and is called the

[328] *Elec. Rev.* (U. S.), Oct. 15, 1921, p. 598.
[329] *Sci. Am. Mo.*, Jan., 1922, p. 33.
[330] *Elec. Wld.*, Dec. 17, 1921, p. 1,211.
[331] *Elec. Rev.* (U. S.), Dec. 10, 1921, p. 888.

"Journal of the Optical Society of America and Review of Scientific Instruments."

A new journal has been started in France called *"Revue d'Optique Theorique et Instrumentale."*

Books.—"Fabrikbeleuchtung," Dr.-Ing. N. A. Halbertsma, (R. Oldenbourg).

"Rayonnement principes scientifique de l'eclairage," A. Blanc, (Armand Colin), Paris, 1921, 212 pp.

"Electric Lighting in Factories and Workshops," Leon Gaster and J. S. Dow, (Sir Isaac Pitman & Sons, Ltd.), London, 1921, 37 pp. See *Ill. Eng.*, Oct., 1921, p. 207.

"Die Lightfilter," A. Hübl, W. Knoppe, Halle, 1921.

"Photographie en Coleurs," L. Godefroy, (J. Lemarre), Paris, 1921.

"Fluoreszenz und Phosphoreszenz im Lichte der neuren Atomtheorie," Peter Pringsheim, (Julius Springer), Berlin, 1921, 202 pp.

"Untersuchungen über den elektrischen Lichtbogen, insbesondere über den unter Druck befindlichen," W. Mathiesen, Kommissionsverlag von E. Haberland, 110 illustrations and 30 tables, Leipzig, 1921.

"Vision et Reproduction des Formes et des Coleurs,"[332] H. Bonasse. One of a series of Bibliotheque scientifique de l'ingenieur et du physicien. XXVI—562 pp. (Librairie Delagrave), Paris.

"The Electric Lighting of Shop-windows," G. K. Fletcher (Benn Brothers, Ltd.), 1921, 38 illustrations.

"Atlas of Slit Lamp Microscopy of the Living Eye," Prof. Dr. Alfred Vogt. Authorized translation by Dr. Robert Von Der Heydt, Chicago. 153 pp., 38 plates with 370 figures. Berlin, Julius Springer, 1921.

"Railway Signaling," Everett Edgar King (McGraw-Hill Book Co.), New York, 370 pp. illustrated.

"The Electric Lamp Industry," G. A. Percival (Sir Isaac Pitman & Sons, Ltd.), London, pp. xxi—109.

"Elektrische Beleuchtungstechnik," Fritz Cloos, zweite Auflage (Johann Hammel), Frankfurt.

[332] *Scientia*, Oct. 1, 1921, p. 315.

THE LIGHTING OF THE MILWAUKEE ART INSTITUTE*

BY HARRY W. BOGNER,** AND ARTHUR J. SWEET, ***

SYNOPSIS: This paper is a study of the lighting problem of the Milwaukee Art Institute. The solution presented by the authors is an interesting treatment of the various phases of lighting as encountered in a building of this description. Illustrations of various rooms, floor-plans of the Institute, and types of lighting units are shown.

In a report on the lighting of the Cleveland Museum of Art, presented before the tenth annual convention of the Illuminating Engineering Society, Dr. E. P. Hyde has shown what highly satisfactory results in gallery lighting can be produced when the building is of a monumental character and architect and engineer are not working under sharp limitations as to permissible expenditure. The following paper presents the application of sound principles of gallery lighting to a building simple in character and shows that sharp limitations in permissible expenditure can be offset, in large part at least, by sympathetic co-operation of building committee, architect and engineer,—by a co-operation that leaves to each his proper sphere of decision and that accepts and works under the limitations defined by the others for their respective spheres.

The Milwaukee Art Institute is not primarily a museum of art; rather, it is the active, functioning heart in the art life of the community. It has, it is true, a worthy art collection of its own: it brings annually to Milwaukee a number of notable traveling collections: but primarily it has for its object the aggressive stimulation of the art instinct of the community and the direction and education of that instinct.

*A paper presented before the Chicago Section of the Illuminating Engineering Society, April 25, 1922.

**Architect, Milwaukee, Wis.

***Consulting Engineer, Milwaukee, Wis.

The growing demands of the work of the Institute made necessary a very considerable enlargement of quarters. It was decided to add a second story to the entire building, to enlarge and still further improve the basement, to rebuild a portion of the first floor so as to provide a much-needed auditorium, to provide first-class lighting service and to re-decorate throughout. This entire work had to be done within the meagre appropriation of $50,000.

Such is the background of the lighting project on which this paper is a report. The analysis and treatment of the problem thus presented can perhaps best be set forth by one of those gallery tours which have proven so effective a method of presentation in the every-day life of the Institute.

Entrance to the building is through an outer and an inner vestibule. The outer vestibule is lighted by a simple lantern in wrought iron and diffracting crystal glass, open at the bottom and fitted within with a concentrating prismatic reflector. This reflector throws the major portion of the light down upon the floor and entrance steps, yet transmits a sufficient portion to light up attractively the lantern itself, though this comes within the normal field of vision only as one steps out of the inner vestibule in leaving the building and starts to descend the steps. The inner vestibule is lighted by an inexpensive yet completely satisfactory unit consisting of concentrating prismatic reflector, shade holder and ceiling receptacle. (See Figures 1 and 2).

Passing through the vestibules, we enter the small exhibit gallery which additionally serves as lobby and as office for a member of the staff who combines with other duties of a clerical nature the reception of visitors. This room is an interior one, receiving by day some light from the front exhibit gallery on the one side and the sky-light lighted stair hall on the other. The natural lighting is, however, scarcely sufficient for close desk work, for best display of art objects or for most attractive effect to the room as a reception room. The artificial lighting is provided by a totally indirect ceiling unit consisting of composition bowl equipped with mirrored reflectors. Mazda C-2 (so-called daylight) lamps employed, 17 generated lumens per square foot of floor space being provided. This totally indirect lighting is especially well suited to the office and reception

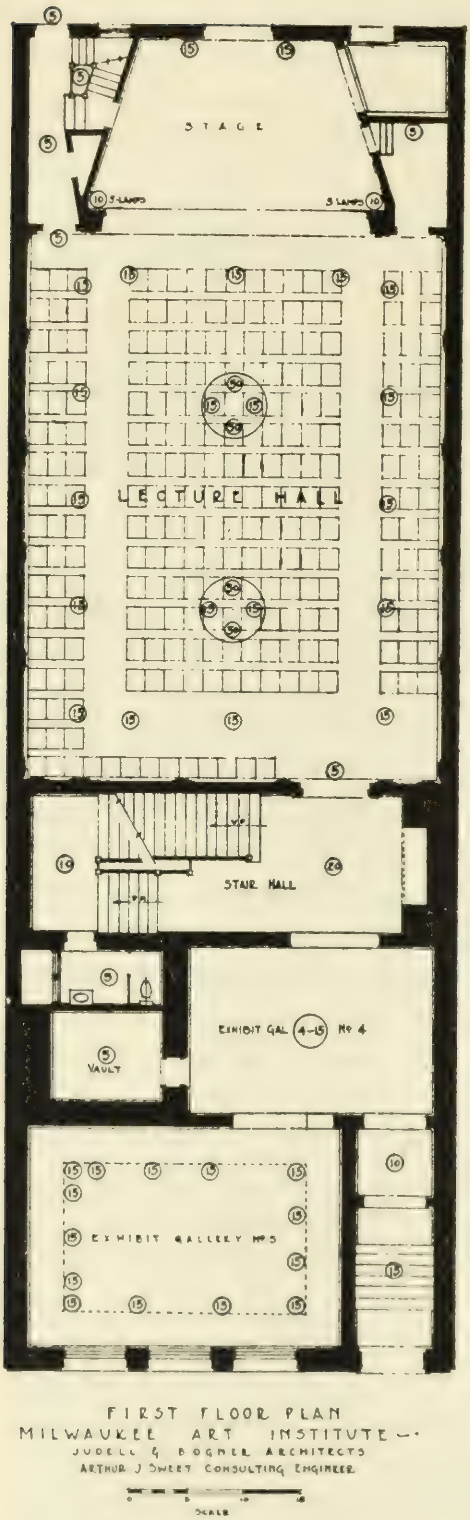

Fig. 1.—First floor plan.

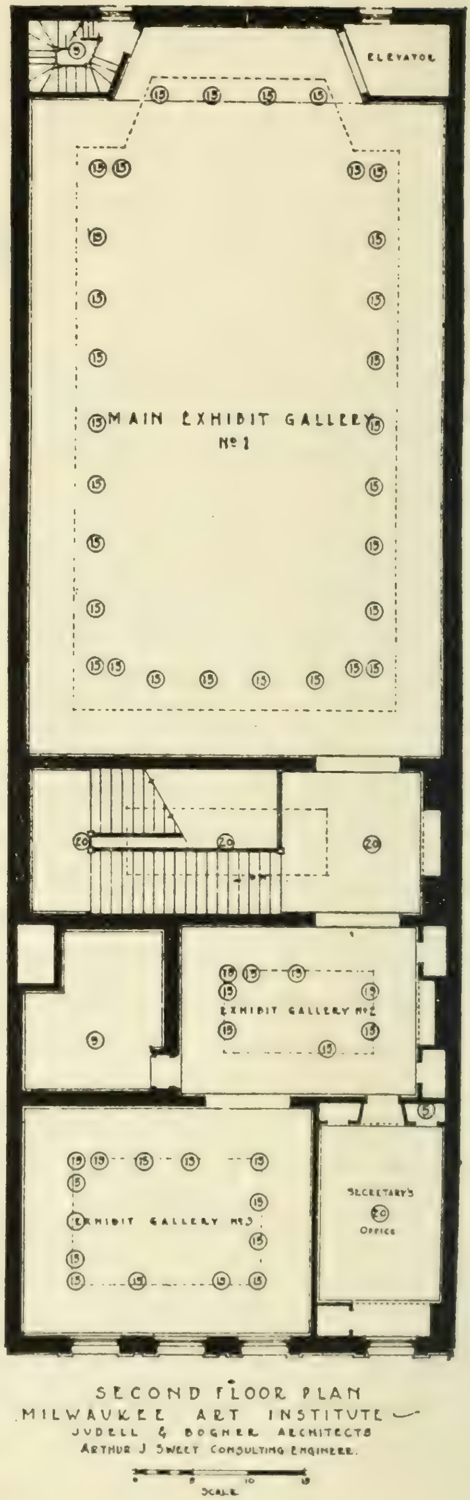

Fig. 2.—Second floor plan.

room requirements and is likewise most satisfactory for the display of art objects other than paintings. For the display of paintings this lighting is fairly satisfactory though not ideal, a faint veiling image of the ceiling overspreading the picture unless one stands well away from it.

We wish first to go to the main exhibit gallery on the second floor, so we pass into the stair hall. Here natural lighting is by sky-light and artificial lighting by luminous bowl indirect units of prismatic glass, supplemented by a single mirrored reflector unit installed above the toning screen of fine thin fabric which hangs below the sky-light. The use of luminous bowl indirect units in the stair hall contrasts pleasingly with the lighting of the adjacent galleries in which a certain atmosphere of quiet, of restraint is sought.

Ascending the stairs, we reach the entrance to the main gallery. Here let us pause a moment to review the requirements of picture gallery lighting.

Of the several major requirements of picture gallery lighting, the avoidance of image reflections from the paint masses of the picture or from the protecting glass undoubtedly comes first. Under natural lighting through ceiling-light from which direct sun-light is excluded, this requirement is usually met. To meet this requirement under artificial lighting involves far greater difficulties. If a so-called "general" lighting system with direct units be employed, there will be certain positions from which each picture can be seen without image reflections, but more positions from which a portion of the picture is absolutely blotted out by a strong image of one of the light units. If indirect lighting be employed, an image of the bright ceiling lightly veils the picture from all positions and is even more objectionable than the images under direct lighting from which escape is possible by change in the observer's position.

The one practical way of avoiding objectionable reflections under artificial lighting is to illuminate each picture chiefly by light which falls upon it at an acute angle (say less than 30°) with the picture surface. In practice this will involve closely paralleling with a line of light units each wall upon which pictures are to be hung and so directing or shielding the light from such units that none is emitted toward other picture hung walls.

A second major requirement is that the lower portions of walls to be used for picture display be lighted to substantially the same brightness as the upper portions of such walls. This requirement is especially important where traveling exhibitions are displayed and change in pictures frequent. If the light units are located in a line closely paralleling the wall, as dictated by the consideration of avoiding image reflections, the substantially uniform lighting of the wall will require a type of light distribution approximating an inverse sine cubed curve. It may be pointed out in passing that each and all of the several types of trough reflectors heretofore extensively used in gallery lighting fail to approximate, even remotely, this correct type of light distribution. Such trough reflectors therefore overlight the upper wall and underlight the lower wall to such degree as utterly to condemn their use.

As every artist knows, light is a most important agent of emphasis. To the illuminating engineer likewise, it is an elementary principle of interior lighting that the center of interest should be treated in proper balance, should be set apart from less significant objects, whether subtly or unblushingly as the circumstances may dictate, by materially brighter lighting. Hence arises a third major requirement of gallery lighting that the picture-hung walls should be much more brightly lighted than any other objects normally falling within the field of vision. A gallery so lighted holds the attention like the drama on the brightly lighted stage. A gallery where visitors move about in as bright a light as that which falls upon the art displayed is like a drama played with the house lights on.

It is difficult to meet this requirement under natural lighting. Louvers above a ceiling-light will serve in part; but the requirement can be met in fully satisfactory degree only under artificial lighting.

The foregoing are the three major requirements but there are other requirements of only slightly lesser importance. The spectral value of the light should approach daylight as closely as possible in order to bring out the true color values of the pictures. Intensities relatively very high as compared with ordinary artificial lighting should be provided in order suitably to bring out the details of the very dark pictures: and in this

connection it must be remembered that to illuminate a picture by light delivered at an acute angle involves great losses in illuminating power through specular reflection. Marked shadows on architectural features of the interior must be avoided or brought to coincide with an architectural line. The light sources themselves must be so treated that they do not attract or at very worst do not hold the attention. Practical considerations of maintenance must not be forgotten: it must be reasonably easy to keep the lighting system clean and in proper adjustment.

All these considerations must be kept in mind, while over all hang the spectres of installation and operation cost: but as a spell of at least partial potency in exorcising these spectres, let it never be forgotten that an art gallery exists to display the art which it houses, and that if this be poorly displayed by improper lighting, all expenditure on architectural features has been in vain.

With these various requirements in mind, we enter the main gallery. As we enter, our attention is irresistably drawn to the picture-hung walls; and this remains true even though the gallery be comfortably filled with visitors. The visitors move about in shadow, as it were, while the pictures stand forth in a strong, clear light, for the moment the greater realities. We note as we move about the room that each picture, from wherever viewed, stands out clear-cut in detail, without reflected image or extraneous high lights of any sort. Studying the illumination further, we become aware that all the room except the walls themselves is lighted from the walls. As we look across the room, the lighting as a whole seems rather subdued; and more critically we turn again to the pictures, half expecting to find them underlighted. But no,—more light would be unnecessary, perhaps undesirable. We note now how uniformly the walls are lighted. Perhaps the upper walls are just a trifle brighter than the lower walls, but the difference is so slight that we can scarcely be sure it exists. We observe that the color values are good but not equal to those under natural light. (See Figures 3 and 4).

And now, as we look toward the ceiling, we experience perhaps some sense of disappointment. The ceiling, save a strip approximately five feet wide adjacent to the walls, is one great panelled ceiling-light. In the center of each border panel is a

slightly irregular, slightly striated bright spot of light. The remainder of the panel glows with a faint light. All other panels save these border panels are, as far as the eye can detect, absolutely dark, completely unlighted. Viewed as a ceiling, as a thing in itself apart from the room, the effect is not wholly pleasing. Then we begin to realize that this effect is substantially unavoidable if that which we have regarded as a major requirement, the strong emphasis of the walls, the subordination of the rest of the room, is to be attained. Further observation convinces us that the ceiling plays only a subordinate part in the effect of the room as a whole. We talk with friends who have seen the room by day as well as by night. They tell us that while the room is architecturally more satisfactory by day, its effectiveness and charm as a picture gallery are greatest under the artificial light,—this despite the fact that the lighting by day has all the desirable qualities of the lighting by night save only the marked contrast between the brightness of the walls and the brightness of other objects.

The means by which the artificial lighting of the main picture gallery is accomplished are quite simple. About 30 inches directly above the inside edge of each outside panel is mounted an extremely concentrating mirrored reflector of a type designed for flood lighting. This reflector is equipped with 150-watt, 1,400-lumen, C-2 lamp. The axis of the unit is directed with great exactness toward a point on the adjacent side wall 36 inches above the floor. The sky-light glass is of ribbed crystal installed with ribs perpendicular to the wall, ribs uppermost. This ribbed glass serves to spread the light longitudinally so as to give sensibly perfect uniformity of illumination along any horizontal line on the wall, while yet but little modifying the distribution in the vertical plane perpendicular to the wall. The distribution in this vertical plane perpendicular to the wall produces a very satisfactory gradual cut-off, free from all sharpness of demarcation, beginning just above the "sky-line" of hanging. The cut-off at the bottom, which occurs along the floor about five feet from the wall, is somewhat more sharply demarcated but not sufficiently so to be at all objectionable, lying as it does in the plane of the floor.

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Fig. 3—Main Exhibit Gallery. View especially illustrating light emphasis on pictures and absence of objectionable reflections from face of pictures.

Fig. 4—General view of Main Exhibit Gallery.

Fig. 5.—Exhibit Gallery No. 3. Displaying Gertrude Schuchardt Collection of etchings.

Fig.6.—Exhibit Gallery No. 5.

One regretable feature of the main gallery installation is its considerable cost. The cost of the reflectors, their holders and the frame-work required for their reliable and rigid support totals approximately $25.00 per unit, not including conduit and wiring costs. It was felt, however, that the importance of the main gallery lighting and the character of the lighting results—which, so far as the authors are aware, could have been obtained from no other available equipment—justified even so considerable an expenditure.

The entire lighting of the main gallery is controlled by a single remote-control switch.

Above the long axis of the ceiling-light, east and west, extends a hipped sky-light, through which the natural light reaches the interior ceiling-light. This exterior sky-light is quite dirty and this has served, up to the present, to tone down what would otherwise be an excessive intensity under natural lighting. It is planned to provide a more constant and more hygienic means of toning down the natural light by painting the south sky-light with a translucent paint.

The use of louvers would improve the natural lighting, but building committee, architect and engineer alike question whether the gain would be sufficient to warrant the considerable cost and the added adjustment and maintenance attention.

A practical feature of importance is the necessity of keeping the upper surface of the inner ceiling-light perfectly clean. To facilitate maintenance, running water and drain have been provided in the ceiling-light loft.

The small galleries are the next point of interest. A typical one is Gallery No. 3, the front gallery on the second floor. Natural lighting is provided for in part by windows but primarily by hipped sky-light below which is hung a toning screen of fine, thin cloth. (See Figures 5 and 6).

The artificial lighting of the small galleries presented a difficult problem. The requirements are, of course, identical with those of the main gallery. The architectural construction, however, imposed the necessity for different treatment. Very satisfactory lighting results could have been secured by employing the same mirrored reflector as in the main gallery lighting, but with ribbed glass held close to the reflector mouth. The cost, however,

was felt to be prohibitive. It was found that, in view of the fact that the units were not to be installed behind a ceiling-light, highly satisfactory results, substantially as good as those afforded by the mirrored reflector—ribbed glass combination, could be secured from a prismatic reflector of concentrating distribution (less concentrating, however, than that of the mirrored reflector in question), used without ribbed glass in front. The cost of the prismatic unit was only about one-eighth that of the mirrored reflector—ribbed glass unit.

The difficulties were far from solved, however, by the selection of a satisfactory lighting unit. In a small gallery, doors, windows and corners represent a relatively large proportion of the wall space. Proper lighting makes necessary, therefore, a very non-symmetrical arrangement of the light units, a feature highly objectionable from the architectural standpoint. Moreover, such a light unit is not particularly ornamental and should be concealed as far as possible. Finally, all light from the unit save that emitted toward the walls should be cut off as completely as possible.

These various considerations are duly met by the construction illustrated in Figure 7. The unit, with axis directed toward a point on the adjacent wall 36 inches above the floor line, is installed just above and back of the edge of the hung screen. Behind the unit a baffle cuts off all light emitted toward the screen. Below, the framework of the hung screen cuts off the downward-emitted light. So nested just behind the screen, the units are quite unobtrusive.

The lighting results are substantially those described at length for the main gallery. The efficiency of lighting and the intensity of illumination are somewhat greater than in the main gallery, due to the closer location of the light units and the absence of the absorptions, reflections and refractions introduced by the ribbed glass. The cut-off, while by no means objectionable, lacks the perfection of the main gallery cut-off. The color value is better.

In the small galleries as in the main gallery, the eye comfort is very noticeable. One is conscious of the same strong sense of comfort that is experienced when, under a brilliant light, one gazes out under the shading hand.

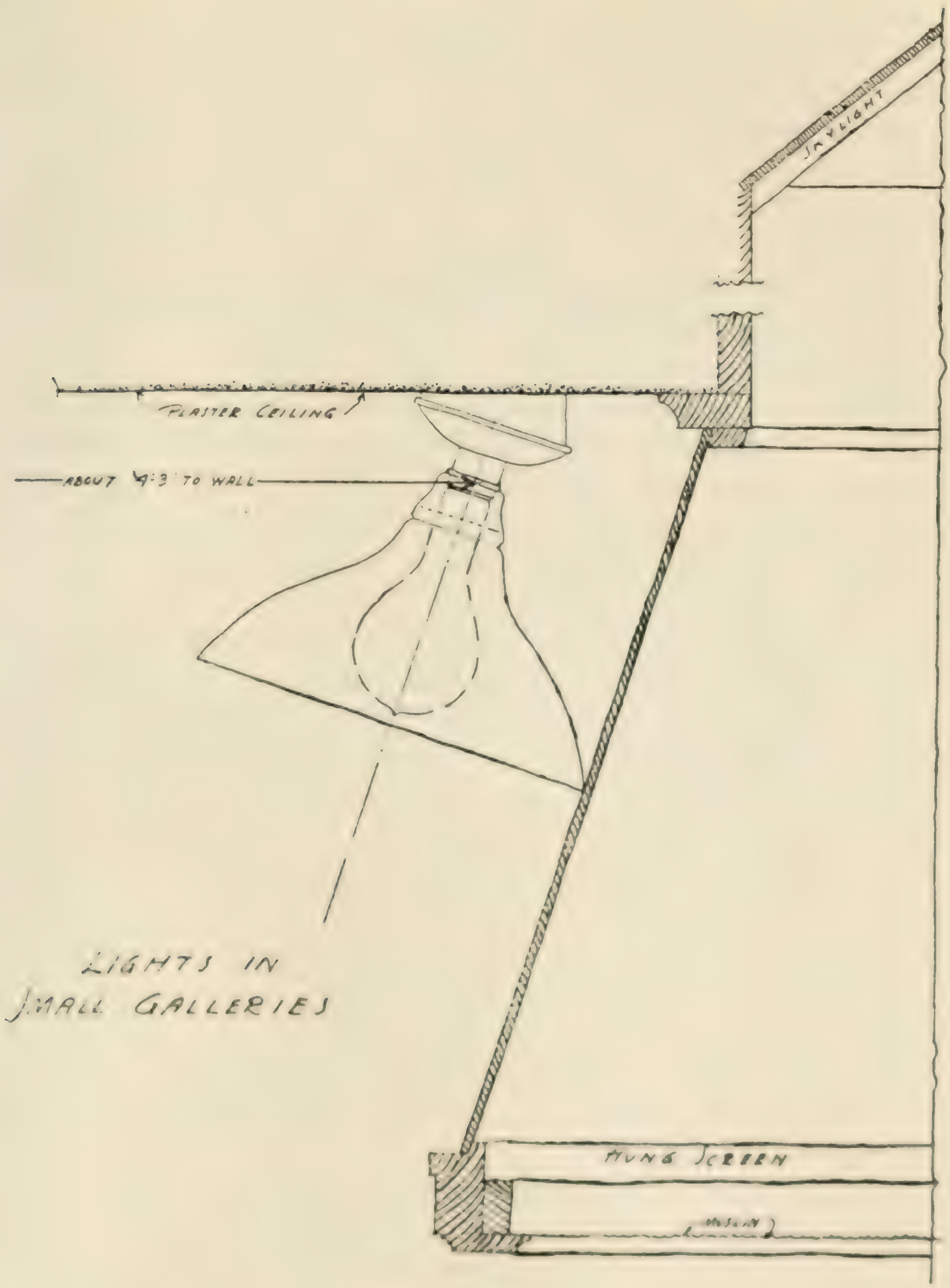

Fig. 7.—Details of unit used in the small galleries.

Our gallery tour now leads to the lecture hall. Here a composite lighting problem, involving many details of difficulty, presents itself.

The lecture hall is, first of all, exactly what its name describes: but it is much more. It is a "little theatre," employed for recitals and for the presentation of the drama. On its walls are hung the choicest of the large pictures possessed by the Institute: when not in use as theatre or lecture hall, it is therefore a picture gallery. These various uses and the resulting importance of providing the lighting emphasis now for the front of the stage, now for the entire stage, now for the picture-hung walls, now for the audience as it gathers for the occasion,— all these require varied lighting treatment under separate control.

What may be called the main lighting though perhaps least used, the lighting of the body of the room used when gathering audience is the center of interest, is furnished by two large indirect fixtures employing composition bowls equipped with mirrored reflectors. These fixtures are hung approximately at the foci of the large ceiling oval.

Incidently, this ceiling oval and the long companion panels on either side constitute a note-worthy feature of architectural interest. They were designed to give length and dignity to a room which, under the limitations of the problem, had to be of rather awkward square proportions. This treatment of the ceiling proved very successful in achieving the results aimed at.

Each ceiling fixture is equipped with two 500-watt, 8,750-lumen, Mazda C units and two 150-watt, 1,400-lumen, Mazda C-2 units. Each set of two units in combination with the corresponding units of the companion fixture are separately controlled, the four larger units by a remote control switch. The three intensities of general lighting thus available correspond to the respective values of 3, 20 and 23 generated lumens per square foot of floor area.

The reflectors of the ceiling fixtures are so directed as to deliver their light chiefly within the ceiling oval.

To harmonize satisfactorily the architectural and illuminating considerations in connection with the lighting of the pictures of the lecture hall was one of the most difficult problems of the entire project. Any fixture at the required locations opposite each wall panel was objectionable from an architectural standpoint, and the essence of the problem was to develop a fixture which, while adequately meeting its service requirements, would represent a minimum of obtrusiveness.

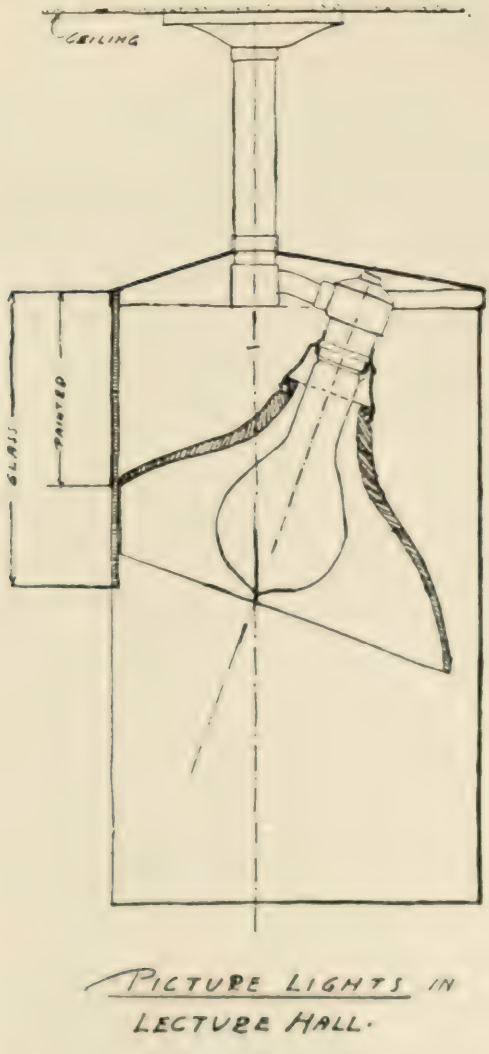

Fig. 8.—Details of unit used in Lecture Hall

Figure 8 (see also Figures 9 and 10) represents the construction finally adopted. A noteworthy feature of the construction was the grinding off of one edge of the prismatic reflector, sacrificing in efficiency slightly thereby, in order both to decrease the size of the required shield and to provide the more conveniently a straight-line cut-off,—a cut-off which, being sharp in definition (though not marked in contrast) was made wholly unobjectionable, indeed a desirable feature, by being made to coincide with the architectural line marking the top of the wall panel. The vertical cut-off afforded by the shield is brought down coincident with the near side of the pilaster, the pilaster

being sufficiently lighted by a penumbra which extends beyond the line of cut-off.

The lighting results closely conform to the picture lighting requirements already discussed. From the architectural standpoint, while it cannot be claimed that these picture-lighting fixtures are a desirable addition, it may fairly be said that they are unobstrusive, that they afford a defense of their presence by their obvious purpose, and that the lighting results make possible thereby much more than compensate for any undesirable element introduced by the fixtures themselves.

The picture lights are controlled by a single remote control switch.

The lecture hall lighting offers an excellent illustration of the principles of picture lighting, heretofore discussed. With all center lights on and the picture lights off, the pictures become merely a detail of wall decoration; while, at practically every point in the room, the image of the brightly lighted oval extends as a partially veiling glare over a portion of one or more of the pictures. With the picture lights turned on and the center lights still burning, the veiling glare becomes but faint and the pictures acquire a new importance in the scheme of decoration. Now turning off the center lights, the pictures, free from image reflections of any sort, become the all-inclusive center of interest.

The stage lighting consists of four different controls, as follows:

Front lights: Three units similar to the picture lights are hung from the ceiling panel in front of the stage and serve to light the extreme front of the stage. These lights are separately controlled from the other picture lights.

Proscenium lights: Five light units installed one above the other at heights varying between 5 feet and 10 feet above the stage floor are provided on each side behind the proscenium arch. Each unit consists of an angle porcelain enameled reflector and 100-watt, 1,260-lumen, Mazda C lamp installed with lamp and reflector axis horizontal and pointing toward the opposite rear corner of the stage. The lamps are equipped with opal lamp caps.

Rear lights: At the back of the stage are two wall indirect units equipped with asymmetric mirrored reflector and 150-watt, 1,400-lumen, Mazda C-2 lamps. The lighting thus provided

serves to improve the stage setting when the stage is in active use and to afford a dim, soft illumination of proper balance for occasions in which the stage has no significant part yet in which it is not desired to draw the stage curtains.

Border and foot lights: At the same time the plans were being prepared it was felt that border and foot lights could not be afforded, at least initially. Accordingly, capacity and circuit reservation were provided at the distribution cabinet, but nothing more. The first month of operation has so emphatically demonstrated the need of both border and foot lights that these will probably be installed in the near future. Indeed, temporary border lights are already installed and in active operation. The foot lights, as planned, involve certain elements of novelty. As has already been noted, the stage is much used as a lecture platform. When so used, the speaker will generally be more effective if he stands well to the front of the stage. This consideration would require that the foot light trough be very narrow. The level of the seats relative to the stage level makes it highly undesirable for foot lights to project above the stage floor.

It is planned to meet these various considerations by use of miniature mirrored glass reflectors, of a type originally designed for show-case lighting, equipped with 25-watt, 226-lumen lamps. These units will be installed on 4¼-inch centers, pointing upward, of course, one-fifth of the units at an angle of 15° from the vertical, four-fifths at an angle of 30° from the vertical. The extreme top of each unit will be one inch below the floor level and the trough in which the units are located will be fitted with removable covers (made in sections) for use when the foot lights are not in service. Five control circuits will be provided, every fifth foot light being on the same control. It is planned to use two controls for white light, and the remaining controls for colored light in the three primary colors, color effects being provided by gelatine removable screens supported in the foot light trough just above the mouth of the reflectors. This arrangement affords great flexibility since, where only one color effect other than white light is desired during an entire evening or where varying toning of white light with any one color is desired, all these controls can be conveniently equipped with screens of the same color, three intensities of this color being thus made available.

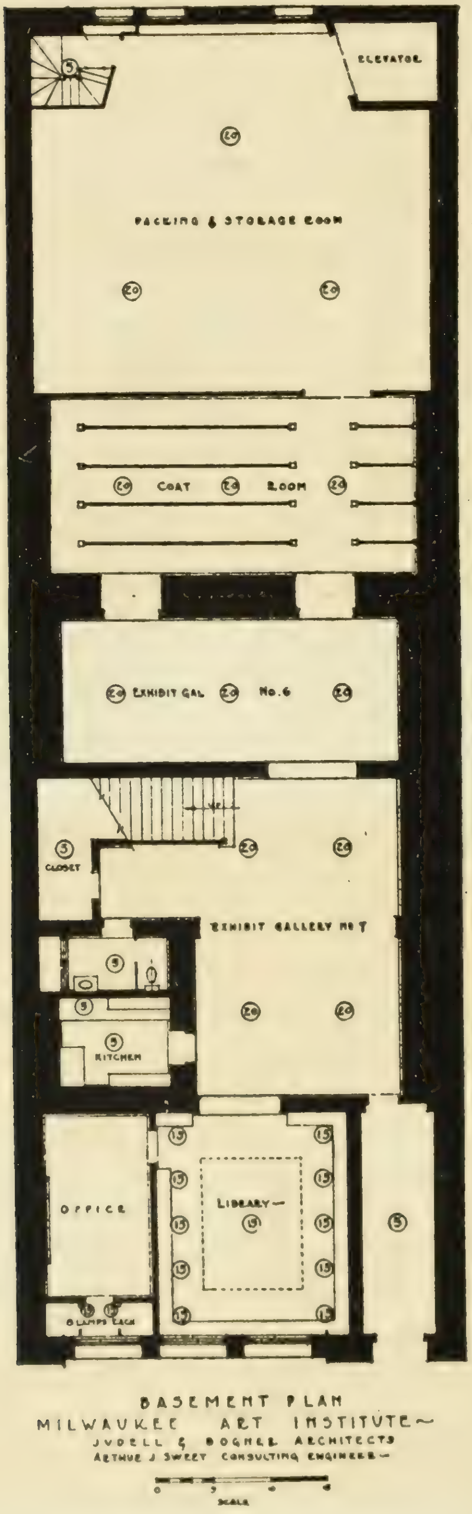

Fig. 11.—Basement plan.

Fig. 9.—Lecture Hall with full illumination.

Fig. 10.—Lecture Hall as lighted for lecture.

Fig. 12.—Library.

Fig. 13.—Director's office lighted by artificial daylight behind glass door.

The entire stage and lecture hall lighting is controlled, either directly or indirectly through remote control switches, by push button switches located in the stair hall just outside the door at the right of the stage. The 150-watt C-2 lamps in the ceiling units of the lecture hall are additionally controlled at the main entrance to the room.

Our gallery tour next leads to the basement floor. Here two rooms connected by broad arch have been designed for use as exhibit galleries. Since in lighting the basement it was felt that sharp economies must be practiced, the lighting unit for these galleries is an extremely one,—an indirect unit made by painting a wooden chopping bowl white inside and gray outside and suspending same by means of a very simple stem fixture. While the installation is unpretentious in the extreme, the lighting results are really very good, the veiling glare due to reflection of the lighted ceiling being surprisingly slight. (See Figure 11).

The library, while used primarily as such, is also used in minor degree for the display of pictures. A feature in the treatment of the lighting problem of this room is the fabric drape dropped from the ceiling parallel to the walls at a distance of 4 feet therefrom. This drape serves the double purpose of hiding certain obnoxious piping which it was impractical to remove and of screening each wall from all portions of the ceiling except the adjacent portion. The light units are reduced to an ultimate of simplicity, consisting of nothing more than a receptacle, and a 150-watt, 1,400-lumen, Mazda C-2 lamp equipped with opal lamp cap. This unit is, therefore, substantially a semi-indirect unit. The pictures being screened from all but the adjacent ceiling, there is a complete absence of image reflection. The one defect of this scheme of lighting, other than its possible limitations in the matter of appearance, is that the upper walls are considerably more brightly lighted than the lower walls.

In the center of the room, within the canopy produced by the drape, a drop cord unit furnishes lighting service for those who may gather around the library table. This unit consists of packing house cord and a semi-enclosing prismatic combination of reflector and refractor which is characterized alike by a broad light distribution approximating an inverse cosine cubed curve and by a sharp recession in light values above an angle of

55°. A fabric shade screens the light unit proper and provides a pleasing if simple effect to the whole. The lighting results are notable both for the distance from the unit at which a good reading light is furnished and for the entire screening of the eye of the reader from the light unit itself. (See Figure 12).

Perhaps the most unique feature of the entire installation is the lighting of the Director's office. Limitations of space made it impractical to provide the Director with an office elsewhere than the basement. The only natural lighting available for this office was a sidewalk window, a narrow, transom-like affair close to the ceiling. Such lighting intensifies the feeling that one is in the cellar,—a feeling scarcely in harmony with an aesthetic atmosphere. Accordingly, it was decided to do away entirely with the natural lighting and provide an effect of day-light by artificial means. A three-compartment cabinet was built across the street end of the office, the central compartment, entered through an ornamental glazed door, being the lighting compartment. The compartments on either side, entered through the central compartment, are designed respectively to serve as small lavatory and as closet for the meters. The central compartment, constructed of asbestos board, is painted white throughout and aquipped with sixteen 150-watt, 1,400-lumen, Mazda C-2 lamps. A glazed semi-circular transom above the door supplements the door as a source of lighting service. When the door is closed, the impression is created that it opens out upon the outside, day-light world. While this type of lighting is relatively inefficient, the total cost for so small a room is a trivial price to pay for affording the Director congenial quarters. This room has aroused much interest and the lighting has met with much favor. (See Figure 13).

Three-way or remote control switches are provided in sufficient measure to make it possible, in proceeding through the building, to light the way in advance and to turn off the lights behind one. An ample number of base-board outlets for vacuum attachment or other service has been provided.

A feature of the installation is the freedom of choice which has characterized the selection of lighting equipment. Mirrored reflectors, prismatic reflectors, white glass reflectors, no reflectors

other than reflecting walls as in the light cabinet of the Director's room and home made reflectors as in the basement galleries,—each of these has been used in just such measure as it seemed best to meet the requirements of each element of the problem.

The entire lighting system was provided and installed at a cost of $5,100 including architect's and engineer's fees. To produce at so small a cost the results herein described has been possible only because of sympathetic co-operation, deference to each other's right of decision within the respective field of each, on the part of the building committee, architect and engineer.

ABSTRACTS

In this section of the TRANSACTIONS there will be used (1) ABSTRACTS of papers of general interest pertaining to the field of illumination appearing in technical journals, (2) ABSTRACTS of papers presented before the Illuminating Engineering Society, and (3) NOTES on research problems now in progress.

GUARDING RAILROAD AND HIGHWAY TRAFFIC BY UNIFORM COLORED WARNING LIGHTS*

BY A. H. RUDD

NOTE—The author is the Chief Signal Engineer of the Pennsylvania Railroad. The article was prepared in connection with signal light conference of the American Engineering Standards Committee. (See TRANSACTIONS, Illuminating Engineering Society, May, 1922, Vol. XVII, No. 5, page 205).

The author points out that the railroads are particularly interested in eliminating the indiscriminate use of red light. They desire uniform signalling systems for protection of crossings at grade, without conflict with their own established practice.

They believe that the unification should be undertaken, and that laws and regulations should be promulgated to enforce observance. Further, they believe that public opinion should be educated to appreciate the necessity of complying with rules of this sort. Uniformity is the foundation, but education is necessary to secure the necessary support from the public.

Statistics show that in the past ten years, 84,000 people have been accidentally killed or injured, while trespassing on railroad property. The fatalities among trespassers have been seven times as great as in train accidents. This type of accident cannot be prevented by signals.

In regard to crossings, the impracticability of stopping trains, whether passenger or freight, to prevent accident, was pointed out.

* Reviewed, *Safety Engineering*, July 1922, page 12.

Because of the nature of the equipments, the train must have the right of way.

The author presented some statistics from the Pennsylvania Railroad which probably represent about 10 per cent of the values for the entire country. In the five months ending February, 1922, which covers a period when touring was relatively small, there were 576 accidents in which 55 people were killed and 251 injured. In a classification of these accidents, it is shown that in 213 cases where automobiles ran through the crossing gates, no one was injured. Further classifications as to day and night accidents, property damage, etc., are of interest. Trying to beat the train, defective brakes and various forms of carelessness are shown to be important cases.

There is need for more strict determination as to who shall be permitted to operate an automobile. The separation of grades is proceeding slowly and is becoming more and more expensive. In the opinion of the author, this is not a complete preventive. The universal adoption of an approach sign, consisting of a white disk with back "X" and the letters "R. R." is urged as a warning that there is a railroad ahead. The black and white crossing gates are regarded by some drivers, while they apparently anger some. Penalties should be exacted for malicious breakage of gates. Most of the railroads use black and white stripes and they should be reserved for this purpose.

The colored lights extensively used on gates should be made universal as should the stop sign in the hands of crossing watchmen. The use of gates should be minimized. Unattended gates in open position are a menace, encouraging people to cross.

The question of automatic signals is being considered by the Signal Section of the American Railway Association, and some uniform arrangement should be adopted when agreed upon. At the recommendation of the Railway Signal Association, several years ago, the railways representing most of the mileage have adopted standard color indications in which red means danger (stop); yellow means caution, green means clear (proceed). Formerly white was used as a clear signal, but was abandoned to avoid the possibility of a broken rondel being mistaken as a clear signal.

The use of red should be strictly limited to meaning danger. Its use to indicate a safe exit in a theatre is wrong in principle, since it should mean stop rather than proceed.

These views are given personally and not as an official statement of the American Railway Association, especially with regard to matters of detail which should be decided later by proper committees.

The author believes that a suitable standardization, supplemented by education, will reduce the amount of police supervision necessary. One difficulty will be to find enough distinctive colors for all purposes. He specifically recommends that the American Engineering Standards Committee adopt the principle that red means stop at highway crossings over railways, at street ends, and possibly to indicate excavations in streets. He further recommends yellow for automobile tail lights, possibly for street excavations or elsewhere to indicate caution, for example, as a warning of changing traffic signals at street intersections.

Green lights are suggested for fire escapes, to instruct street traffic to proceed and otherwise indicate that the way is clear.

In connection with the proposal to use yellow for automobile tail lights, the author urges that automobile clubs, manufacturers, salesman, etc., unite to change the laws and educate those responsible for such equipment. (Note—when the yellow tail light was proposed at the A. E. S. C. conference, Mr. A. L. McMurtry took strong exception to it, anticipating extreme confusion in breaking up a practice so well standardized, and involving motor car owners in an unnecessary expenditure which would, in the aggregate, be excessive).

In conclusion, suggestions were made as to the part various groups should take in effecting color standardization and education.

Headquarters of the Sixteenth Annual Convention, New Ocean House, Swampscott, Mass.


View of Hotel from Jeffries' Point.


View of Hotel and Annex from the Sea Wall.

SOCIETY AFFAIRS

CONVENTION NOTES

The Sixteenth Annual Convention of the Society will be held at the New Ocean House, Swampscott, Massachusetts, September 25, to 28 inclusive.

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R. F. Whitney

SUB-COMMITTEES

Finance

H. K. Morrison, *Chairman*
Charles S. Davis
David Crownfield
F. A. Gallagher, Jr.
Robert S. Hale

Publicity

Merle Griffeth, *Chairman*
A. W. Devine
Louis Gibbs
J. B. Grace
Frank K. Hirons
T. J. McManis
Ralph C. Rodgers
James H. Toohey
E. H. Whitney
P. B. Zimmerman

Entertainment

C. A. B. Halvorson Jr., *Chm.*
G. W. Bicknell
John Campbell
J. J. Cadigan
J. E. Greene
J. E. Livor
James Palsick

Attendance and Local Arrangements

Arthur W. Marion, *Chairman*
F. W. Bliss
J. W. Cowles
D. McFarlan Moore
M. D. Riley
Frank L. Sample
C. A. Strong
L. R. Wallis

PROGRAM

MONDAY, SEPTEMBER 25

10:00 A. M. to 12:30 P. M. .... Registration
2:15 to 5:00 P. M. .... Open Session
Evening .... Reception and Dance

TUESDAY, SEPTEMBER 26

9:15 A. M. to 12:30 P. M. .... General Papers Session
2:15 to 5:00 P. M. .... General Papers Session
Evening .... Grand Water Carnival

WEDNESDAY, SEPTEMBER 27

9:15 A. M. to 12:30 P. M. .... General Papers Session
2:00 to 5:00 P. M. .... Inspection Trips and Entertainment
Evening .... General Session and Entertainment

THURSDAY, SEPTEMBER 28

9:15 A. M. to 12:30 P. M. .... General Papers Session
2:15 to 5:00 P. M. .... General Papers Session
Evening .... Banquet

1922 CONVENTION PAPERS PROGRAM

MONDAY AFTERNOON, SEPTEMBER 25, 2:15 P. M.

Address of Welcome, ... Dr. Elihu Thomson
Presidential Address .... Dr. George S. Crampton
Report of the Council by General Secretary .... Clarence L. Law
Report of Committee on Progress .... F. E. Cady, *Chairman*
Report of Committee on Nomenclature and Standards .. Clayton H. Sharp, *Chairman*
Report of Committee on Education .... F. C. Caldwell, *Chairman*
Report of Committee on Motor Vehicle Lighting ...... Clayton H. Sharp, *Chairman*

TUESDAY MORNING, SEPTEMBER 26, 9:15 A. M.

Lighting Statistics of Representative Urban and Suburban Homes .... Norman D. MacDonald
A Survey of Residence Lighting .... M. Luckiesh
Report of Committee to Prepare Bulletin on "Residence Lighting by Electricity" S. G. Hibben, *Chairman*
Report of Committee to Co-operate with Fixture Manufacturers (A tentative outline) .... M. Luckiesh, *Chairman*
How to Tell Period Styles in Fixtures .... J. W. Gosling

TUESDAY AFTERNOON, SEPTEMBER 26, 2:15 P. M.

Performance of the Tungsten Filament Lamps on Alternating and Direct Current... John W. Lieb
Overcoming Daylight Reflections in Show Windows .... Ward Harrison and H. T. Spaulding
Effect of Light on the Drawing Power of the Show Window .... W. Sturrock and J. M. Shute
Lighting for Public Eating Places .... J. L. Stair

WEDNESDAY MORNING, SEPTEMBER 27, 9:15 A. M.

Lighting for the Food Industry..............................W. H. Rademacher
Practical Application of the Principles of School Lighting............H. B. Dates
Office Lighting from the Viewpoint of Hygiene....................A. B. Emmons
The Cost of Daylight..........................M. Luckiesh and L. L. Holladay
Lighting for Motion Picture Studios................................F. S. Mills

WEDNESDAY EVENING, SEPTEMBER 27

Symposium—A Fifteen Year Advance in the Art of Lighting—Presented by Authors of Papers given at the Society's First Convention at Boston, 1907. Comments on Present Practice.
Messrs. Sharp, Millar, Marks, Bell, Ryan, Hale, Blood, Morrison, Walker, and others.

THURSDAY MORNING, SEPTEMBER 28, 9:15 A. M.

A Direct Reading and Computing Attachment for Sphere Photometers............
B. S. Willis
The Regular Icosahedron as a Substitute for the Ulbricht Sphere..................
B. E. Shackleford and K. S. Weaver
A Distribution Photometer of New Design..
C. C. Colby and C. M. Doolittle
Plotting of Spectrophotometric Data..............................F. A. Benford
Flicker Photometry—Parts I and II......................C. E. Ferree and G. Rand

THURSDAY AFTERNOON, SEPTEMBER 28, 2:15 P. M.

Measurement of the Electrical Response of the Retina to Stimulation by Light......
E. L. Chaffee and W. F. Bovie
Report of Committee on Sky Brightness...................H. H. Kimball, *Chairman*
Lighthouse and Lightship Lighting.................................S. G. Hibben
Some New Graphical Methods and Their Application in the Calculation and Comparison of Luminous Flux...............................C. O. Mailloux
Influence of Daylight Illumination Intensity on Electric Current Used for Lighting Purposes in the District of Columbia.................A. Smirnoff

ENTERTAINMENT

The entertainment features of the convention will include automobile trips to points of historic interest, and to plants of the General Electric Company and the Edison Electric Illuminating Company of Boston.

For those who play golf, tournaments have been arranged at a time which will not conflict with the regular business sessions. Card games for the ladies and a putting contest are also included in the program. The banquet will be held Thursday night, to which all delegates to the convention are invited.

The Entertainment Committee has planned several novel features which will be in the nature of surprises.

The advanced registration indicates that this will probably be the largest convention in the history of the Society. Inasmuch as the committee is making special arrangements for the ladies, it is hoped that delegates will bring their wives where possible.

CONVENTION BRIEFS

Of special interest this year will be the grand illumination Tuesday evening. A beautiful stage back of the hotel lends itself beautifully to an illumination effect. In the center of the stage fireworks will be shown and pyrotechnics will outline the entire shore for a considerable distance. A large amount of headlighting equipment will be used throughout the grounds and electrical requirements are such that a special power arc will be run around the hotel grounds for our purpose.

There will be on exhibit for the first time in this part of the country a new 30-kilowatt incandescent lamp. Marine pyrotechnics, illumination of water craft and a special flood lighting display will be of interest to all.

His Excellency, Channing H. Cox, Governor of the Commonwealth of Massachustetts, has courteously consented to address the banquet on Thursday evening, and in addition to this, other distinguished guests include Rear Admiral Wiley, Commander of the First Naval District, Major General Clarence R. Edwards, Commanding General, First Corps Area, Captain Franklin D. Karns, Commanding Officer of the Charlestown Navy Yard.

The presence of the U. S. destroyer, J. Fred Talbot, is assured and is to be anchored in the harbor of Swampscott directly in front of the New Ocean House during the period of the Convention. Commander G. B. Mayo will be with the destroyer.

There should not be a dull moment for the ladies as concerts, automobile rides, dancing, golf contests, teas, motor boat rides, musicales, bridge tournaments and other features have been prepared for their entertainment. A feature of this Convention will be the opening of the tea-room to the lady delegates without charge.

Arrangements have been made for the use of a large automobile bus to leave Park Square, Boston at 1:00 P. M. Monday, and 9:30 A. M. Tuesday to Thursday inclusive, to facilitate transportation to Swampscott. This bus will leave Swampscott, returning to Boston at the close of the afternoon sessions and should greatly stimulate the attendance.

A great deal of interest has been aroused in New England concerning the Sixteenth Annual Convention of the I. E. S. Indications point that the Central Stations, Gas Companies, Fixture and Jobbing Houses will have a large representation at the business sessions.

The Chicago Section wishes to formally advise all other Sections that it intends to again take the attendance prize at the national convention at Swampscott A large delegation from Chicago is assured.

Due to the fact that all the delegates to the convention will be housed under one roof, everyone will be benefited by the excellent program of entertainment laid out by the Committee in charge of Mr. C. A. B. Halvorson, Jr., of the General Electric Company.

COUNCIL NOTES

Upon recommendation of the Board of Examiners the following were elected to membership at the July 13th meeting of the Executive Committee:

Three Members

CHARLES A. COLLIER,
General Sales Manager,
Georgia Railway & Power Company,
Electric and Gas Building,
Atlanta, Georgia.

FRANK S. MILEY,
Assistant Manager and Technical Adviser,
American Eveready Works of National Carbon Co., Inc.,
Thompson Avenue and Orton St.,
Long Island City, New York.

FRANK A. PIM,
1404 McGavock Street,
Nashville, Tenn.

Eight Associate Members

GEORGE AINSWORTH,
Manufacturer of Luminaires,
101 Park Avenue,
New York, N. Y.

H. H. ASHINGER,
Sales Engineer,
Westinghouse Electric & Mfg. Co.,
South Bend, Indiana.

CHARLES H. BAY,
Illuminating Engineer,
Detroit Edison Company,
2000 Second Street,
Detroit, Michigan.

ROSCOE I. BEHAN,
Asst. Field Engineer,
Automobile Club of Southern Calif.,
1344 So. Figueroa Street,
Los Angeles, Calif.

ARTHUR BROCK, JR.,
Mgr. of Machinery Mfg. Company,
Arthur Brock, Jr. Tool & Mfg. Wks.,
533 No. 11th Street,
Philadelphia, Pa.

EMORY HILL,
Opthalmologist,
501 E. Franklin St.,
Richmond, Virginia.

ERIC PARNELL,
Illuminating Engineering Division,
Edison Electric Illuminating Co.,
39 Boylston Street,
Boston, Mass.

THOMAS G. WARD,
Illuminating Engineer,
Detroit Edison Company,
2000 Second Street,
Detroit, Michigan.

One Transfer to Full Membership

ALVIN L. POWELL,
Lighting Service Dept.,
Edison Lamp Works,
5th and Sussex Streets,
Harrison, N. J.

Upon recommendation of the Board of Examiners the following were elected to membership at the August 24th meeting of the Executive Committee.

Two Members

LEWIS C. CONANT,
Illuminating Engineer,
Buffalo General Electric Company,
Electric Building,
Buffalo, New York.

WILLIAM GRAHAM WOOD,
Vice President and Manager,
Berkeley Light Corporation,
Humboldt Bank Bldg.,
San Francisco, Calif.

Nineteen Associate Members

CLARENCE L. ALLIS,
Secretary and Treasurer,
Wooster Electric Company,
Public Square,
Wooster, Ohio.

E. J. DAILEY,
Western Electric Company,
195 Broadway,
New York, N. Y.

W. F. Dansbee,
Lighting Specialist,
Southwest General Electric Co.,
522 Interurban Bldg.,
Dalles, Texas.

Edward George Dolezel,
Student of Electrical Engineering,
10506 Union Avenue,
Cleveland, Ohio.

Morris Herbert Gens,
Electrical Engineer,
Wm. Gens and Son,
53 Hawthorn Street,
Chelsea, Mass.

William S. Hake,
Manager Fixture and Wiring Depts.,
Brown & Pierce Company, Inc.,
2 Franklin Street,
Rochester, New York.

Lee D. Hall,
Commercial Agent,
Alabama Power Company,
Huntsville, Alabama.

Yoshijiro Ishikawa,
Directer and Manager,
Commercial Dept.,
Kyoto Electric Light Company,
Kyoto, Japan,

James Bernard Kelly,
Rehabilitation Assistant,
U. S. Veterans' Bureau,
1037 U. S. National Bank Bldg.,
Denver, Colorado.

Isaac Mark, Jr.,
Illuminating Engineer,
New York Edison Company,
15th Street and Irving Place,
New York, N. Y.

Chasaburo Metsuda,
Research Student at Kyoto Imperial University,
Electrical Engineering Dept.,
Kyoto, Japan.

Richard C. Moore,
Lighting Dept.,
Wetmore Savage Co.,
76 Pearl St.,
Boston, Mass.

Dr. J. B. Nathanson,
Assistant Prof. of Physics,
Carnegie Institute of Technology,
Pittsburgh, Pa.

Josiah Crosby Norcross,
Assistant, Supt. Installation Dept.,
Edison Electric Illumination Co.,
39 Boylston Street,
Boston, Mass.

Lucien C. Priest,
Meter Tester, Edison Electric Illuminating Co.,
1165 Mass. Ave.,
Boston, Mass.

H. J. Shaw,
President Electrical Specialties Co.,
325 State Street,
Detroit, Michigan.

Frederick Francoz Simms,
Director of Trades School,
Virginia Normal and Industrial Inst.,
Ettrick P. O. Station,
Petersburg, Virginia.

Clarence Cook Walker,
Salesman,
Wetmore-Savage Company,
76 Hampden Street,
Springfield, Mass.

John Willy,
Editor and Publisher,
The Hotel Monthly,
443 So. Dearborn Street,
Chicago, Ill.

One Transfer to Full Membership

Darwin Curtis,
Illuminating Engineer,
National X-Ray Reflector Company,
235 W. Jackson Blvd.,
Chicago, Ill.

SECTION ACTIVITIES

CHICAGO

Mr. Ward Harrison, President-Elect of the Illuminating Engineering Society, was in Chicago early in September, and held several informal conferences with active members of the Chicago Section. As a result of these conferences the Board of Managers will probably decide to conduct a lecture course on "Illumination" exclusively for architects.

Plans for the coming year are now being made and it is expected that most of our meetings will be held jointly with other societies for the purpose of letting them know of the recent activities and accomplishments of the I. E. S.

A good number of members have signified their intention of taking a real active interest in Society affairs and doing all possible to increase the membership of the Chicago Section.

PHILADELPHIA

The new Chairman-Elect, Dr. Howard Lyon, has had a preliminary meeting during the summer to consider the activities of the coming season and chairmen tentatively selected, pending the time for their official appointment. It is intended of the various committees have been that the papers this coming season will be along practical rather than scientific lines.

NEW ENGLAND

Great interest has been shown during the summer in the work for the coming convention by the members in the Boston district. Section activities have given way to convention details.

NEW YORK

Informal plans have been discussed by the incoming Board of Managers. A meeting of the new officers with the old Board of Managers has been held.

CLEVELAND

New officers for the coming year have been nominated and will be elected during September. The officers of the chapter will be announced at the coming convention.

TORONTO

The members of the Toronto Chapter are looking forward to a very energetic season. Last year's officers are to be congratulated for their accomplishments not only in their work connected with the Chapter, but also for the enthusiasm which they have stirred up in the Illuminating and Electrical engineering men of Toronto.

There are several Business Mens' Organizations located in Toronto who are now looking to the Society for advice in illumination, from both an illuminating and architectural standpoint, this advice is given with the greatest of pleasure by the members of the executive. Several interesting lectures have been held during the past year, dealing with all phases of illumination and we are pleased to say that the interest shown has more than compensated the Society for the work entailed in arranging for speakers of pre-eminence to address them.

PERSONALS

Mr. G. Bertram Regar, recently elected Vice-President of this Society, has been further honored in being elected to the Chairmanship of the Lighting Sales Bureau of the National Electric Light Association. His Executive Committee consists of some thirty members, representing central stations and lamp manufacturers throughout the country, who are all well known in the electrical industry and can be counted on to energetically carry out the Bureau's policy of one hundred per cent co-operation with the more and better business campaign.

It is of interest to note that the entire personnel are members of and actively interested in the work of the Illuminating Engineering Society.

Thomas W. Rolph has been appointed Managing Engineer of the Street Lighting Department of the Holophane Glass Co., Inc., 342 Madison Avenue, New York, N. Y., with Works at Newark, Ohio.

Mr. Rolph is a graduate Electrical Engineer of Cornell University 1907. After finishing college he was Commercial Engineer for the Holophane Company until 1913. From 1913-1920 he was employed in the metal reflector division of the General Electric Co.

Mr. Rolph's new duty with the Holophane Company will be to promote scientific street lighting.

Mr. H. Calvert, after having been for twenty years with the Philadelphia Electric Company, as Designing Electrical Engineer, has resigned from that position and is now President of the Baird-Osterhout Company, who are Electrical Contractors and Engineers, in Philadelphia, Pa.

Prof. F. C. Caldwell, of the Electrical Engineering department in Ohio State University has recently been elected to the Board of Councillors of the Eye Sight Conservation Council of America.

Mr. C. S. Davis, Boston District Mgr., of the Westinghouse Lamp Co., who has been on a two months' pleasure trip in Europe, returned on Sept. 7, 1922.

Mr. J. H. Lynch formerly of the Geo. Cutter Co., South Bend, Ind., has been assigned to the Boston office of the Westinghouse Elec. & Mfg. Co., as District Illuminating Sales Engineer.

Mr. O. H. Perkins, formerly with the Stuart-Howland Co., Boston is a member of the new firm of Perkins, Carpenter Electrical Supply Co., at 90 High Street, Boston.

Mr. W. T. Blackwell, formerly with the George Cutter Works of the Westinghouse Electric & Mfg. Company, at South Bend, Indiana has recently become affiliated with the Public Service Electric Company, of Newark, N. J., as manager of the Lighting Bureau.

ILLUMINATION INDEX

PREPARED BY THE COMMITTEE ON PROGRESS.

An INDEX OF REFERENCES to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

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The Pupil and Visual Acuity (Editorial)—		July	585
American Journal of Physiology			
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Die Wiederherstellung ausgebrannter Glühlampen—		No. 102	837
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Some Gas Burners and a Moral—	C. Carpenter	June 28	853
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TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

VOL. XVII | OCTOBER, 1922 | NO. 8

A Message
From Our New President

WITH ITS EXCEPTIONAL attendance and enthusiasm the Swampscott Convention just closed could scarcely fail to inspire everyone who was present with a new faith in the future of the Society and with a renewed purpose to work for the attainment of those principles for which it stands. A brief quotation from a convention paper of a year ago suggests also that the opportunity for such work is not far to seek.

"While illuminating engineers have enunciated certain principles and methods of lighting which have been applied with gratifying success to some extent, the fact remains that the general practice of lighting still lags far behind the methods known to the engineer. The great public still remains strangely ignorant of or indifferent to the advantages of good lighting."

Is it not true that this attitude of indifference on the part of the public is more apparent than real and that it is in fact simply an evidence of the general lack of familiarity with modern lighting methods and even with the simplest of the fundamentals involved? Nevertheless, the burden comes back again to the Society; it must not only devise new and better ways of lighting but it must educate the public to their use as well. And as the bulk of the knowledge in the possession of the Society and its members grows, just so does the obligation to disseminate information increase. The case was well put at the Convention when someone said that "the Society as a whole might well resolve itself into a Committee on Education."

Every architect, oculist, consulting engineer, every member of the Society, through his own personal contacts can do much toward furthering the knowledge of good lighting and by the same means he can provide a most substantial support to the Society in its organized effort directed through schools and colleges, special lectures and other courses to promote proper lighting education.

Ward Harrison

REFLECTIONS

A Welcome Change of Procedure

IN THE past there has been frequent criticism of the illuminating Engineering Society for being too scientific and not devoting enough attention to the application of fundamentals to commercial problems. This objection can hardly be raised this year. The papers and discussions were intensely practical; still, the more scientific subjects which must always be the basis of professional society activity were not neglected. The grouping of subjects for discussion was especially commendable since it induced the attendance of practicing engineers and commercial engineers who must be depended upon to put the best thought on illuminating problems into execution. Besides, it brought them into contact with the devotees of science who congregated on the last day of the convention. This intermingling of commercially and scientifically inclined minds cannot help to be beneficial.

Another innovation was the interpretation of every paper by means of the abstract published with it. A continuation of this practice will help to draw hitherto uninterested persons into I. E. S. activities if advance publicity is given to the interpretations through affiliated organizations and if they are emphasized by chairmen in introducing the speakers. Incidentally such treatment may prevent high-class contributions from moldering on library shelves.

Two other lessons might be learned from this and previous conventions. First, the ample material made available through this society should be used more extensively to educate architects, contractors, fixture dealers and the public in the fundamentals of good lighting. Second, renewed attempts should be made to bring about closer co-operation between men of the callings just mentioned and illuminating engineers. The Illuminating Engineering Society, as an organization, may be counted upon to do its part. In addition, individuals must study how they can help—and then do something.—EDITORIAL, *Electrical World*, Oct. 7, 1922.

Illumination of the Brazilian Centennial Exposition

ON REQUEST of Dr. Carlos Sampaio, President of the Exposition Commission and Prefeito of the City of Rio de Janeiro, W. D'A. Ryan, accompanied by A. F. Dickerson, assistant Engineer, and J. W. Gosling, Decorative Designer of the Illuminating Engineering Laboratory, went to Rio de Janeiro, Brazil, to design a scheme and scope of illumination for the Brazilian

Centennial Exposition which opened September 9, 1922, to commemorate the one hundredth anniversary of the independence of the United States of Brazil. The illuminating effects finally decided upon are similar in many respects to the illumination of the Panama-Pacific International Exposition held in San Francisco in 1915. The main buildings and grounds are flooded with light from masked cartouche and banner standards, supplemented by ornamental luminaires mostly of the so-called lantern type.

The relief lighting in the towers, minarets and windows is rose, red and orange, to give depth, texture and atmosphere. The floral effects for the most part are in masses of solid color which are brilliantly featured in illumination.

Flags and special features are lighted by incandescent searchlights so as to stand out strongly against the blue-black background of the sky. The entire composition is dominated by a scintillator in ever changing colors.

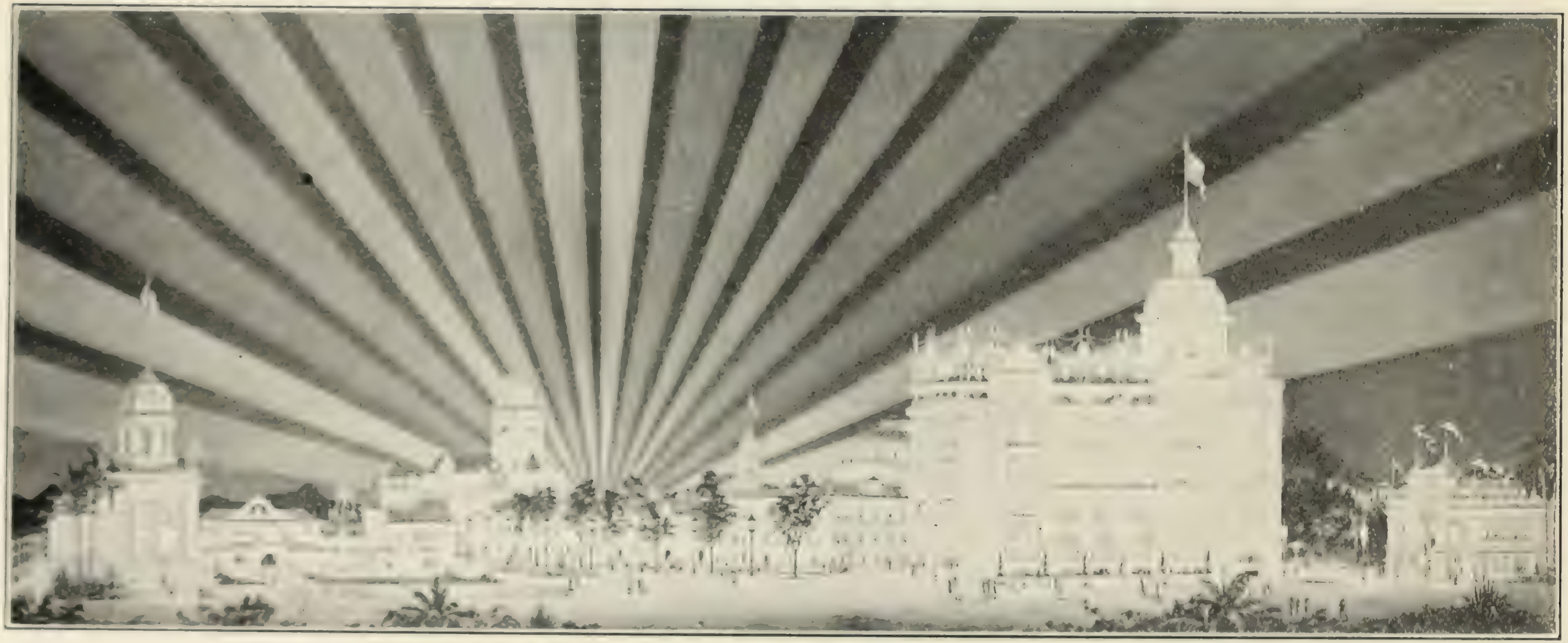
The roof and dome of the Palace of States is treated with 40,000 Novagem jewels which enhances the beauty of the structure and adds much to the carnival spirit, not only at night in the artificial light, but in the daytime under the rays of the sun.

In addition to the main exposition building, Ihla de Fiscal, situated on a crescent of the beautiful bay at a distance of about half a mile from shore has its quaint building of German Gothic architecture bathed in softly colored light. On either side are palm trees, which at night stand out in scarlet against the darkness and harmonize in effect with the banner standards, light from the windows and colored relief lighting of the structure. While this island is approximately half a mile from the north entrance to the Exposition, the colors are reflected in the water and the general effect of this beauty spot is one never to be forgotten by those fortunate enough to visit the Exposition.

The amusement section of the Exposition is treated in outline lighting accentuated by carnival effects in color. The Exposition grounds proper cover approximately fifty acres. The interior illumination is more of a conventional order in harmony with the architectural and decorative treatment. The total cost of the lighting, installation and operation is approximately half a million dollars.

While this is a national exposition, it is in reality international; twenty-two foreign nations are represented and the United States Government has appropriated a million dollars for participation.

The American, British, French and several other nations have constructed buildings which serve as permanent Embassies. The picturesqueness of the city of Rio de Janeiro is beyond description and the features, especially at night, surpass in certain respects any illuminated spectacle heretofore created.



View Showing Illuminating Effects in North Garden, Brazilian Centennial Exposition, September, 1922.

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The installation was made by the Brazilian General Electric Company, under the supervision of J. W. Schaffer of the Illuminating Engineering Laboratory, sent from Schenectady.

The electrical department is under the able management of one of Brazil's most eminent engineers—Dr. Roberto Marinbo, assisted by Dr. Eugenio Hime. W. D'A. RYAN.

Investigation of the Conditions in Residence Lighting

TWO papers on the conditions governing residence lighting were brought out by the convention of the Illuminating Engineering Society, both of them based on a careful survey of residence lighting as it is. The studies were intended to cover all types of residences, although in the average they dealt, as any statistical investigation must necessarily deal, mostly with middle-class living conditions. The total number of living quarters considered reached several thousand, and the averages obtained were, on the whole, probably as representative as could be wished. From this study several interesting features of practice emerged which perhaps were hardly looked for.

In one of the investigations the rather surprising fact was elicited that in the average house considered the artificial lighting was almost or quite as good as the natural, the fact being that in small houses, particularly in crowded city quarters, the window space is small, so that the distribution of light is bad, and in many instances the interior finish is such as greatly to reduce the effect of natural daylight even a few feet inside the windows. Dark decorations in fact proved to be one of the bad features in ordinary domestic illumination. On the whole, the values for artificial lighting were adequate if properly utilized, and where the lighting was bad the cause was unskillful dealing with the facilities at hand.

The usefulness of fixtures installed by the average speculative builder, or even by the casual owner of a house, depends very largely on two factors—how much is left of the building appropriation after everything else has been taken care of and what the fashion of the moment in decoration may be. For instance, at the present time, as has happened periodically in the past, most decorators seem to think it necessary to inflict on their clients conventional and expensive wall brackets which for illuminating purposes might just as well be non-existent, particularly when the room finish is dull, as it sometimes is in the very rooms that need the most light, to wit, libraries.

It was found, as was to be expected, that on the whole people who owned their own homes went to more trouble and expense

in insuring proper lighting equipment than did those who were merely renting. But even the better class of owned houses showed a good many failings in the matter of equipment and particularly as regards convenience outlets. These ought to be rather numerous to avoid too much stringing of lamp cords. Such outlets are valuable not only for electrical appliances of various sorts, but for the portable lamps which in many rooms furnish the best available means for suitable illumination. The average provision for watts output per socket was in general found satisfactory. The total wattage, however, falls short on account of the inadequate number of outlets generally found, so that, roughly speaking, it is not much more than half what would be desirable for a well-lighted house properly equipped with conveniences. The main reason for the lack of an adequate number of outlets is the extremely high cost of wiring brought about not only by the cost of material and labor but by restrictions which add to it a large unnecessary factor. Much of this needless expense is due to underwriters' requirements which ought to have been thrown overboard long ago.

In addition, some trouble is undoubtedly due to lack of wisdom on the part of electrical contractors and workers who do not realize yet that cheap and effective methods of wiring in the long run mean an increase of use which will bring prosperity to the very men who now stand in the way.

The whole survey shows clearly the need of a general overhauling of wiring methods and material with a view to finding out what our neighbors across the Atlantic have long known, how to carry out house wiring in the interest of the man who has to pay for it and use it.—EDITORIAL, *Electrical World*, Oct. 14, 1922.

PAPERS

ADDRESS OF WELCOME*

BY ELIHU THOMSON**

It is with much pleasure that I welcome the Illuminating Engineering Society to our home town, Swampscott, where I have myself lived for over thirty years. I hope that the Society will be favored in every particular, and that the weather during the Convention will be ideal for the meetings, such that the impression taken back by those who live at a distance may be altogether favorable.

Mr. C. L. Edgar, who has done so much to assist the holding of the present Convention, used to be a near neighbor, as was also Mr. E. W. Rice, Jr., late President of the General Electric Company, and Mr. George E. Emmons, now Vice-President, but formerly Manager of the Schenectady Works. I may add, also, that a number of other prominent men, particularly Mr. Charles A. Coffin, who is well known and who was for many years the President of the General Electric Company, lived about a mile away in Lynn in the early days of the organization.

Those of you who may not be familiar with the North Shore must learn about it. It is justly famous for its many miles of fine beaches, its roads, its woods, its picturesque towns and villages, not only along the shore, but far back in the rural country beyond. The streams are clear, the foliage at this time of year of glorious tinting and the views over hill and dale have a wonderful charm. There are doubtless places more blessed as to climate, but if "variety is the spice of life," we have it here, and the New England normal fall is a season unequaled for bright, sunny days, with a crisp, invigorating chill in the air which stirs all our energy. The country, through its roads and other matters, is highly developed for automobile touring.

*Presented at the Annual Convention of the Illuminating Engineering Society, Swampscott, Mass., September [illegible], [illegible].

**Consulting Engineer, General Electric Co., Lynn, Mass.

The Illuminating Engineering Society is not responsible for the statements or opinions advanced by contributors.

The work of an illuminating engineer may be said to be a certain combination of science and art, and it has grown up well within the past half century. My own recollection easily carries me back to the use of whale oil, lard oil, and camphene, a mixture of turpentine and alcohol, which, along with candles and outside of the comparatively limited use of gas, where the illuminants of my early boyhood. Houses fitted with gas were advertised as choice, the gas supply being advertised as a sort of luxury, very much as was the case with the later introduction of bathroom and toilet facilities, as also hot water.

In those far-off days of fifty or sixty years ago, the usual gas burner was an iron burner, with two small holes throwing jets of gas against each other, so as to spread the flame out into a sheet. It was not an efficient burner, as the burner itself grew very hot. Then, about 1860, came the introduction of what was termed "coal oil," otherwise known as kerosene, which began to be supplied in new types of lamps instead of the old camphene and oil lamps, as soon as the pumping of oil began in the Pennsylvania oil fields. The whole oil industry, in fact, has had its enormous development during the period well within my own experience. The enormous stores of oil underground lay untapped, until the drive-well principle was used to pump from them. There is no need now to dwell upon the extensions of the oil industry, the energy and avidity with which new sources of supply are sought and brought into being.

I have mentioned the gas burner, and the first improvement I remember was the introduction of the so-called "lava tip," of which there were two varieties, known as the "fish tail" and the "bat's wing" burners. The fish tail burned from four to five cubic feet of gas an hour, while the bat's wing might go as high as ten. These terms were used to indicate the general shape of the flame produced.

So the illuminating art proceeded, until about forty-five years ago, when a new standard was set. The beautiful light source known as the "carbon arc," which had only been seen in laboratories and by few people, began to be looked upon as a commercial possibility for lighting large spaces. This was based upon the invention of the dynamo machine, driven by engine power,

but the light itself was a large unit, highly efficient in light production, and there came with it the question for the problem—as we may choose to call it—known as "the sub-division of the electric light," meaning by that, that the electric light was the arc light, the only one known, and that it would be desirable to cut such a light source into fractions and distribute them about. A great amount of misapprehension has arisen in the minds of many as to the real meaning of "the sub-division of the electric light," and many scientific men of high standing have been quoted as very foolishly asserting, or at least taking the attitude that the sub-division was an impossibility. This dictum has been often quoted to their discredit, when in reality they were right, and the fact remains to-day that "the sub-division of the electric light" has not been accomplished, and never will be. They pointed out that the production of light in small units would involve great loss in output of light per unit of power, and that is exactly what would happen.

Edison, however, had the merit of looking at the problem from an entirely different standpoint. His object was to produce a unit of light which would replace a gas burner, and if it should cost in power very much more than the same amount of light produced by an arc, he was willing to accept the disadvantage and set it against the superior distribution. When I saw, in Menlo Park, in December, 1879, the Edison exhibit of the first carbon incandescent lamps, it was plainly evident that little more than 100 candlepower could then be obtained from incandescent lamps per horsepower expended, while ten times that amount of light was given by an arc with the same power. Gains in efficiency of incandescent lighting of course have been made, and will be referred to.

It is curious to note that in the early days of the introduction of electric lighting, one of the arguments in favor of gas as against electricity was that by burning gas, one obtained not only the light but the heat, and that a building would, therefore, require less coal to heat it in the winter if gas were burned. This was a peculiar argument, indeed, since it was known that the hot air so obtained was full of deleterious gases, the products of combustion, and that increased ventilation would be necessary to remove

those gases, so that the air would be proper to breathe. If this were done, of course the heating effect would be lost along with the hot gases escaping.

It was early seen that the success of electric lighting in any form, and especially in the form of incandescent lamps, would depend upon cheapening the power. The engines of those early days were non-condensing, and rarely required less than five or six pounds of coal to the horsepower hour. Not only, then, was there need of improvement in the efficiency of the lamps, but the generation of power at greater and greater efficiency was also a problem involved. The development, although gradual, and the period while this was going on, was marked by the bringing out of the mantle light, or Welsbach burner, used with gas, which undoubtedly had a great effect in the production of light from gas, and as such the efficiency was about doubled, or even more than doubled.

However, progress went on until at last the tungsten vacuum lamp gave the same light as the earlier incandescent lamps, for about one-third of the power, and the half-watt lamp cut this in half again, or made it one-sixth of the power. At the same time, the huge turbine plants, together with utilization of water power, cut down the cost of power production to a degree, which, twenty-five or thirty years ago, could hardly have been anticipated, and yet progress must not stop. We must be continually on the alert to discover better means of light production and cheaper power production, if such be possible.

The ideal light, such as the kind of light given off by the firefly, is one which is often called a "cold light." In reality, as you all know, light is only luminous heat or radiation which affects the eyes, and is identically the same in character as the radiation which we cannot see, as the infra-red of the spectrum, or the higher radiation which we cannot recognize by sight, that is, the ultra-violet rays; even including X-rays and the gamma rays of radium. To obtain a light in which the radiant energy used or the heat energy is all luminous may not be a possibility, but somehow, we cannot help regarding the fact that the firefly has indeed solved that problem. We, with our laboratory facilities, have been engaged upon the working out of this problem for

scarcely fifty years, while the firefly, in its process of development, probably has to its credit during its evolution hundreds of millions of years, so that the actual invisible heating effect of the firefly radiation is practically negligible. There is evidently plenty of work for the future, but it may be that eventually the work of the chemist may really solve problems of this character, in producing, by chemical methods and from cheap materials, the particular substance, whatever it is, which is oxidized by the firefly. It is well known that the light of the firefly is extinguished when oxygen is cut off, as when the firefly is put in an atmosphere of hydrogen, so that the process of light production is really one of slow combustion.

In conclusion, allow me to congratulate the Illuminating Engineering Society on the apparent success which is to be anticipated at this Convention, and to again reiterate my greeting of welcome to the Society in its visit to the North Shore.

THE ILLUMINATING ENGINEERING SOCIETY ITS IDEALS AND CHARACTER*

BY DR. GEORGE S. CRAMPTON

Although your retiring president has been deeply interested in the aims and aspirations of the Illuminating Engineering Society for many years, he has always retained for himself the privileges of an outsider, an outsider within the fold, one who although enjoying all the advantages of membership as though he were really an Illuminating Engineer, nevertheless stands away as it were, in order to allow a better view or estimate of what the Society really means to the public and to its membership.

What is the type of this group of men who have banded themselves together in a common interest? Are their aims alone altruistic and scientific or coming as they largely do from the various industries in which light is turned into dollars are they blinded to the real fundamental good that their profession can do for mankind?

This standing away at times in order to obtain a better perspective gives one a wider angle—a more nearly unbiased view point from which people and events appear in their true relationship.

In the present instance the results of the bird's eye view have been most reassuring and pleasant. Big men have been seen to offer the hand of encouragement and real help to those less well equipped, mentally and physically, for the battle of life.

Jealousies, great and petty, are always with us but here they appear to loom very small and harmless.

Commercialism has only to raise its head and one of the old guard is ready to say gently but firmly—"You have your place, a very legitimate place but that place is *not* in *this* Society."

So here we have a society, the very foundations of which are commercial—composed of a group of men who cherish a sentiment that leads them to higher levels, to the higher plane of scientific fact.

* The Presidential Address presented before the Annual Convention of the Illuminating Engineering Society, Swampscott, Mass., September 25-28, 1922.

In the science of their art they find a new religion. A *religion* which binds together the people of the World—makes them speak the same language—causes the same sort of heart throbs wherever they may be.

What could be more beautiful than the science of light? Can we find fault with the ancient worshippers of the sun? Truly a beautiful religion it was and always will be.

So it should not surprise one to find that the society which delves into the science of light is a society of the highest ideals and character.

"Character" may be taken as "the sum of the qualities which distinguish." It manifests itself most obviously by acts. "By their fruits ye shall know them." A more subtle quality leads us to *appraise* character in cases where we lack knowledge of *acts* which might reveal it. This quality expresses itself through its very existence as an undemonstrated force which is sensed without being manifested.

It is this latter mark of high character upon which Emerson dwells at length in his classic essay.

In science the Illuminating Engineering Society pursues the truth without regard to the effect of its findings. While not ignoring expediency and while recognizing the importance of *timeliness* and *tact in all things,* it adheres to and promotes truth.

In art the Society seeks beauty. The artist is welcome in the Society's councils. Reconciliation of the viewpoints of the artist and the engineer is a cherished hope toward the consummation of which progress is being made. We who supply and apply light, control the great medium of beautification. "There is nothing either beautiful or ugly but lighting makes it so."* The Society seeks to learn how to beautify by means of lighting and to spread the knowlerge for the benefit of all.

In service the Society's attitude and endeavor are philanthropic. Its Constitution fixes upon the dissemination of knowledge as one of its fundamental activities. Knowledge of lighting principles and of means of applying them brings to the public greater economy, added beauty, and better health. Toward these ends the Society is bending its efforts.

* Paraphrase of Hamlet's line "There is nothing either good or bad but thinking makes it so."

In method the Society is ethical. The success it has attained in securing co-operation among the diverse elements of its membership and in harmonizing competing commercial interests evidences the rectitude and broad-minded conduct of its activities.

In management the Society has proved by its activities in organizing lecture courses which define in scope and outline the practice of illuminating engineering; by its technical committee work in advancing the science and art of illumination; and by its service to the nation during the war that it possesses a fair degree of enterprise. In view of the perennial change in administration the record to date is perhaps all that could have been expected. But considering the vast opportunities for service in the lighting field it would seem that larger achievements are possible in the future.

The membership comprises those who design objects which it is desired to see; those who provide light with which to see them; and those who conserve the organs with which they are seen. These three classes of members join this Society to promote mutual understanding and to better their respective services to the public.

The less tangible qualities which are difficult of verbal description are perceived clearly through the respect which the working membership displays for the reputation of the Society; and through the devotion and often the self-sacrifice which characterizes their service. Committees operate with a tacit understanding that no breath of suspicion as to purity of motive must be permitted to be attached to the Society's attitude or acts. These things come to pass because the members sense the high character of the Society and interest themselves to uphold it. It is the more remarkable therefore that larger numbers have not been attracted to its membership. For some reason the Society appears to lack magnetism for outsiders despite the possession of attractive qualities which are quickly realized by those active in its service.

Having then an organization which seeks the true and the beautiful and which, in an enterprising and ethical manner, engages in a philanthropic service it is no wonder that those who serve it come to feel a measure of interest and even of affection

which transcends *that* usually engendered by service in technical societies. The Illuminating Engineering Society is of a character that commands such an attitude on the part of its servants. Happily success in its work, while contributing to philanthropic ends, at the same time promotes the commercial interests of those rightly and properly engaged in the lightng industry. Thus while advancement of commercial interests is incidental and occupies a position of secondary importance, commerce finds in our Society a common ground with altruism.

There are philanthropic organizations; there are scientific societies; there are professional societies; and there are commercial associations. But, the Illuminating Engineering Society is distinct from all these. It draws its membership from several distinct professions, arts and businesses. It engages in scientific work in the development of an art and in education and philanthropy. The diversity of its membership and the diversity of its activities, all revolving about the art of lighting, render it *distinctive,* if not unique among organizations.

Thus, by reason of its acts; by reason of its rare qualities; and by reason of its unusual composition and function, the character of the Society has been established beyond peradventure. It is a character which commands the respectful adhesion and the *unstinted service* of its membership.

LIGHTING STATISTICS OF REPRESENTATIVE URBAN AND SUBURBAN HOMES*

BY NORMAN D. MACDONALD**

SYNOPSIS: A description of the illuminating engineering features of a survey which has been made by a committee of the Association of Edison Illuminating Companies in New York, Chicago, Boston, Detroit and Rochester.

Statistics are supplied for areas of rooms, watts of incandescent lamps, representative foot-candle readings by day and night, wall decorations, cleaning period of fixtures and lamps, number of wall or baseboard receptacles, visibility of bare lamps. etc.

The conclusion reached, after a study of these statistics, is that the public in general is not informed of the advances in illuminating engineering in the past ten years and is not guided by the generally accepted principles in the lighting of homes.

INTRODUCTION

During the summer of 1921 the Association of Edison Illuminating Companies through a sub-committee*** of its Lamp Committee engaged in a survey of residence service conditions in certain cities in which member companies of that Association operate. Through the courtesy of these committees the illuminating engineering data of this survey have been released for presentation before the Illuminating Engineering Society. The author desires to express to these committees his appreciation of the privilege they have afforded him in making the data of this paper available.

This survey was undertaken by the participating companies with the idea of studying and improving residence service. The illuminating engineering data which form only a part of the information obtained were secured as one means towards this end. The data secured were necessarily limited, but it is felt that most of the information is accurate and dependable and may be used as a base line for the measurement of future progress.

* A paper presented at the annual convention of the Illuminating Engineering Society, Swampscott, Mass., September 25-28, 1022.

** Asst. to General Manager, Electrical Testing Laboratories, New York City.

*** Personnel of Sub-Committee: Clarence L. Law, *Chairman*; J. F, Becker, William A. Durgin, Miss S. M. Sheridan, L. R. Wallis, T. H. Yawger; Norman D. Macdonald, *Secretary*.

Where however the returns rest upon the surveyors' judgment, there is of course some question of reliability.

Extent of Survey.—This survey was participated in by

The New York Edison Company
The United Electric Light & Power Co. of New York
Commonwealth Edison Co. of Chicago
Edison Electric Illuminating Co. of Boston
Rochester Gas and Electric Corporation
The Detroit Edison Company.

The statistics were analyzed by the Electrical Testing Laboratories.

For each company, two hundred and fifty residences were chosen whose yearly bills were estimated to approximate the average for residence consumption of electricity in the city.

Conditions Under Which Survey Was Made.—Each residence was visited by a surveyor and a recorder whose equipment consisted in a set of survey forms, a foot-candle meter, a foot rule, and a small camera. In all, about one hundred men engaged in the surveying. These men were representatives of the local central station company, and were chosen carefully. Except in a very few cases, none had had any illuminating engineering training, but a short training school was held in advance of each survey, and the men were coached carefully in the methods of securing the data and the reasons for securing them. A survey sheet for each residence covered, among other things, the lamps in each room, the decorations, daylight conditions and typical illumination values. In the living rooms only, a more extensive study of the luminaires was made. The survey in each residence took about one hour.

The information secured, while fairly complete for the purpose, represents a compromise between a desire to secure full information and a disinclination to inconvenience the householder.

General Statistics.—In this paper the data will be indicated for the average of the houses, or the average of the apartments, all cities being combined. The following table contains general statistics underlying the deduced data which will be shown hereafter:

TABLE I.

STATISTICS OF RESIDENTIAL INSTALLATIONS

	**Average no. rooms	Average *area sq. ft.	Average no. people	Average no. operative lamps	Total watts lighting installation	No. surveyed
			APARTMENTS			
High city	§9.9	1,117	4.3	17.5	856	273
Average	7.8	831	3.6	14.7	664	144
Low city	‡6.1	563	2.9	10.9	502	52
			HOUSES			
High city	12.2	1,550	4.9	21.0	950	222
Average	10.4	1,232	4.6	19.4	859	138
Low city	9.3	1,047	4.2	16.9	760	61

*Exclusive of attics and cellars.

**Includes any lighted area enclosed by walls, such as halls, closets, baths, etc.

§"High city" indicates the highest average value for any one city.

‡"Low city" indicates the lowest average value for any one city.

TABLE II.

AREA OF ROOM IN SQUARE FEET

	Hall	Living	Dining	Kitchen	Bed	Bath
			APARTMENTS			
High city	76	183	162	126	138	55
Average	66	164	152	108	116	45
Low city	55	141	134	73	93	30
			HOUSES			
High city	83	197	172	147	156	59
Average	71	190	166	130	132	55
Low city	49	181	160	116	121	53

Sizes of Lamps (Figure 1).—The distribution diagrams shown in this figure indicate the predominance of the vacuum type lamp of the 25 to 60-watt ranges. There is no general use, at the present time, of gas-filled lamps. The average watts of the lamps in apartments is 45.3 and in houses is 44.1.

TABLE III.

WATTS OF LAMPS INSTALLED PER SQUARE FOOT OF ROOM AREA
AVERAGE OF ALL CITIES

Type of residence	Halls	Living room	Dining room	Kitchen	Bed room	Bath
Apartments	0.73	1.16	0.95	0.59	0.60	1.15
Houses	0.67	1.09	0.82	0.53	0.44	0.89

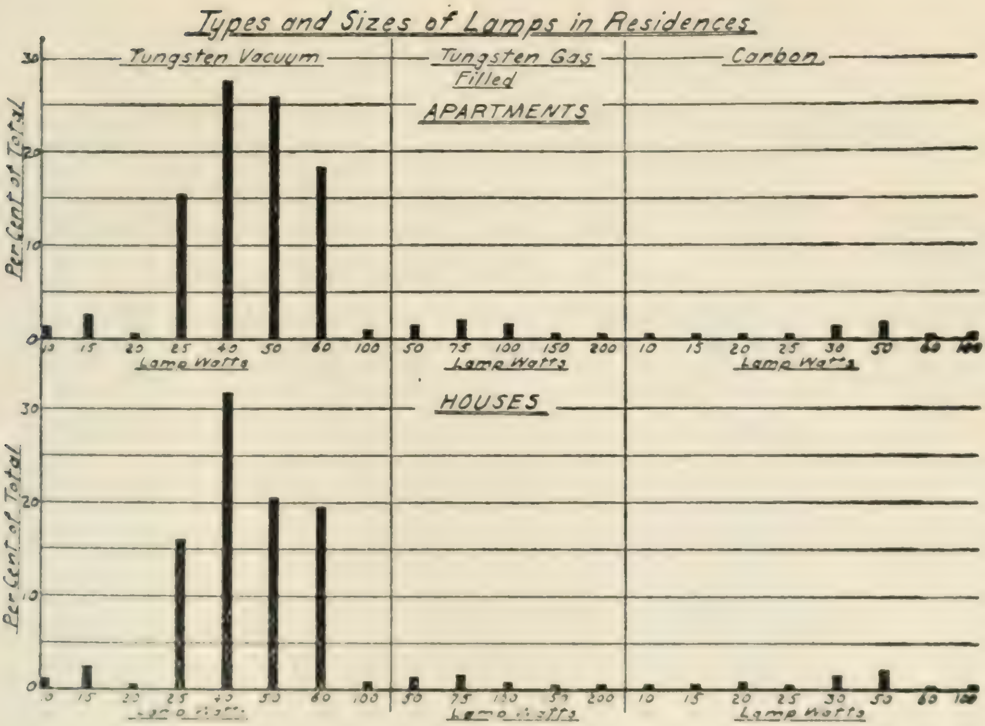


Fig. 1.

These data are determined from the operative lamps installed in the various rooms shown. The figures approximate the watts per square foot used in lighting these rooms with the possible exceptions of the dining and living rooms where it is found that normally only a portion of the total installation is used. The variation in these two rooms appears to be due to two causes: (a) turning off a portion of the lamp load in normal times, the reserve lighting being used only at the time of some special function; (b) the replacement of original equipment by table or floor lamps, making a portion of the original installation superfluous. Later data from another source fixes the per cent of lamps normally used at from 66 to 75 per cent for such rooms.

One reason for the low watts per square foot of used equipment in dining and living rooms is the spotty character of the illumination. In general, fairly high illumination is found on the dining table and at the center of the living room. The intensities fall off rapidly as the sides of the room are approached.

TABLE IV.

REPRESENTATIVE FOOT-CANDLES—DAY AND NIGHT

	Apartments				Houses			
	Daylight		Artificial		Daylight		Artificial	
Rooms	No. rooms meas.	Avg. ft. cand.	No. rooms meas.	Avg. ft. cand.	No. rooms meas.	Avg. ft. cand.	No. rooms meas.	Avg. ft. cand.
Halls	676	1.2	130	1.7	684	1.6	77	1.7
Living rooms	662	8.9	98	4.1	433	3.4	59	4.2
Dining rooms	599	6.1	87	3.6	434	3.4	68	4.8
Kitchens	704	7.2	75	3.6	453	4.5	70	4.1
Bedrooms	1,652	6.7	205	2.6	1,499	3.3	220	3.1
Baths	737	6.5	84	3.2	434	3.2	70	5.0

The values given represent the average of at least three measurements taken at representative points in each room. As an example, in measuring dining room illumination, night or day, a measurement was made at the head of the table, at some representative position at the side of the table, and at some side room position, such as top of a serving table, sideboard, etc. The values therefore, show an attempt to determine the mean intensity at the most used points of the room. The higher daylight illumination in apartments is probably due to the relatively larger window space and relatively smaller rooms.

Wall Decoration and Daylight (Figure 2).—This figure shows the proportions of rooms having good, fair and poor natural lighting, contrasted with the proportions of rooms having light, medium and dark decorations. In both apartments and houses there is a tendency to use of dark decorations in dining rooms, living rooms and halls. In general, the proportions of respectively light, medium and dark decorations are as those of good, fair and poor natural lighting. The tendency, is to assist the natural lighting in bed and bath rooms with decorations of light tone.

Wall Decoration and Daylight (Figure 3).—A greater proportion of dark decorations were found in poorly lighted rooms. In discussion of this fact with a number of men engaged in the survey, a variety of explanations was elicited, some of them as follows:


DAYLIGHT & DECORATIONS IN RESIDENCES.
APARTMENTS
Good
Fair
Poor
DAYLIGHT
DECORATIONS
Light
Medium
Dark
HALL
LIVING
DINING
KITCHEN
BEDROOM
BATH
HOUSES

Fig. 2.

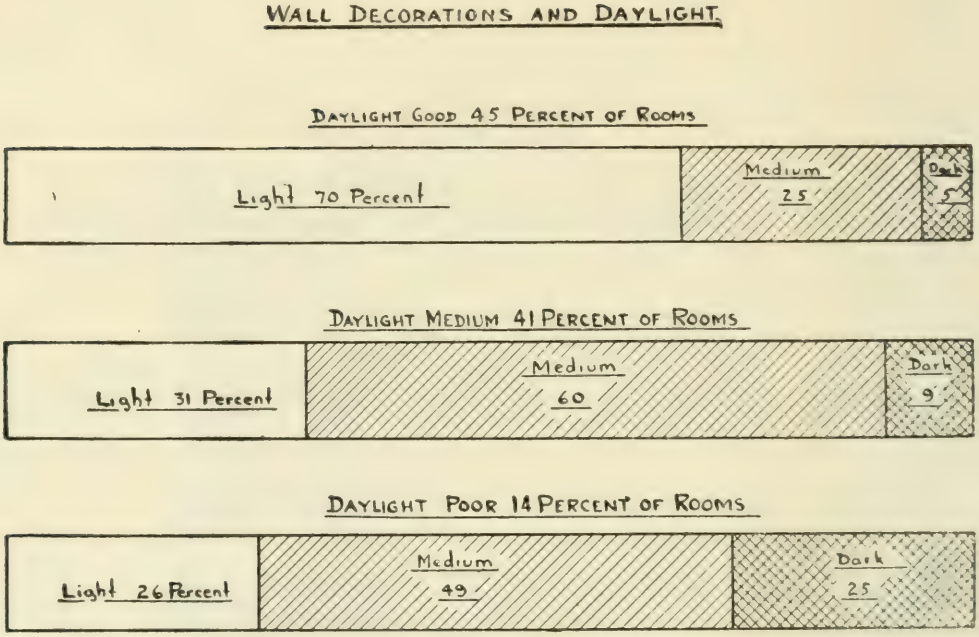


Fig. 3.

1. Dark walls are used for decoration of certain rooms which are usually in the darker portions of the house, such as dining rooms, dens, etc., and decoration, and not daylight, is the chief factor considered.

2. With little daylight, very light walls may present too much contrast and therefore be out of harmony with the general decoration.

3. Sleeping rooms and bath rooms which are usually decorated in light tints are often situated where they receive the best natural light.

4. Wall paper and paint are often selected in shops without reference to daylight conditions in the room where they are to be placed.

It is plainly indicated that there is opportunity for improvement in lighting conditions through the employment of lighter tints in decoration, where this can be accomplished without doing violence to the desired appearance of the rooms.

Uses of Lighting Sockets.—About 5 per cent of the total number of fixed lighting sockets are found to have been fitted with

cord and plug to lead the current to some more convenient point for use in either a portable lamp or appliance.

Of the sockets remaining for strictly lighting use, 85 per cent are used in lighting; 1 per cent contain burned out or broken lamps, 3 per cent are empty, although normally in use, and 11 per cent are empty through disuse. This last figure is usually explained through the obsolescence of some sockets of the rigid luminaires, through the substitution of gas-filled lamps, using fewer sockets, or through the substitution of portable lamps.

TABLE V.

Statistics of Uses of Lighting Sockets in Residences

	Per cent sockets devoted to cord and plug	Total remaining sockets surveyed	Distribution of sockets less those devoted to cord and plug: Containing lamps — Operative	Containing lamps — Burned out or broken	Empty — Ordinarily used	Empty — Not used
			APARTMENTS			
High city	7.5	3,530	88.5	1.7	6.3	16.4
Average	5.3	2,387	83.0	0.9	3.3	11.9
Low city	3.3	990	79.4	0.0	1.3	8.1
			HOUSES			
High city	7.4	5,180	92.0	1.4	2.8	13.3
Average	5.2	3,163	86.8	0.8	2.3	10.1
Low city	3.1	1,219	81.0	0.2	1.4	8.4

TABLE VI.

Total Lighting Sockets and Receptacles

	Residences surveyed	Lighting sockets	Receptacles	Lighting sockets & receptacles	Avg. no lighting sockets per survey	Avg. no. receptacles per survey	Avg no total outlets per survey
Apartments	947	16,952	720	17,672	17.9	0.76	18.7
Houses	550	13,362	1,084	14,446	24.3	1.07	26.2

Accessibility of Lamps (Figures 4 and 5).—The statistics collected indicate that in 75 per cent of the cases lamps may easily be removed from fixtures and that in the other 25 per cent the changing is attended by some inconvenience. This is a point to be remembered in considering the question of dust collection and consequent reduction of illumination as the fixture which is difficult to reach is the one in which dust is most likely to be allowed to accumulate.

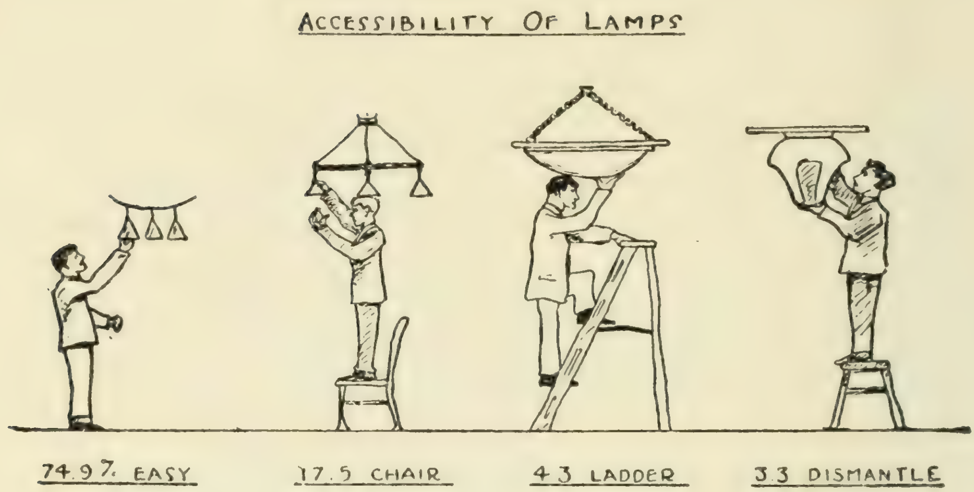


Fig. 4.

Figure 5 presents a study of these data, room by room. The indication is that the lamps which are difficult to change are usually found in hallways. This is probably due to the use of some form of lantern, or totally enclosing globe. In other rooms, the variation is not marked, but indicates the presence of more complicated luminaires in living and dining rooms.

Wall or Baseboard Receptacles in Various Rooms (Figure 6).— The wall or baseboard receptacle or "convenience outlet" to use the newly coined term, is employed in only one-quarter to one-half of the cases where it might be used. A very striking feature in this chart is the difference in the use of "convenience outlets" in apartments and houses. The houses have twice as many outlets as the apartments. It would appear that the reason for this is that the speculative builder can see no profit in increasing the number of outlets. The home owner, however, provides the convenience outlet for his own comfort. In apartments, it is probable that neither the tenant nor the landlord cares to go to the expense of installing outlets, therefore lamp cords from luminaires are used instead.

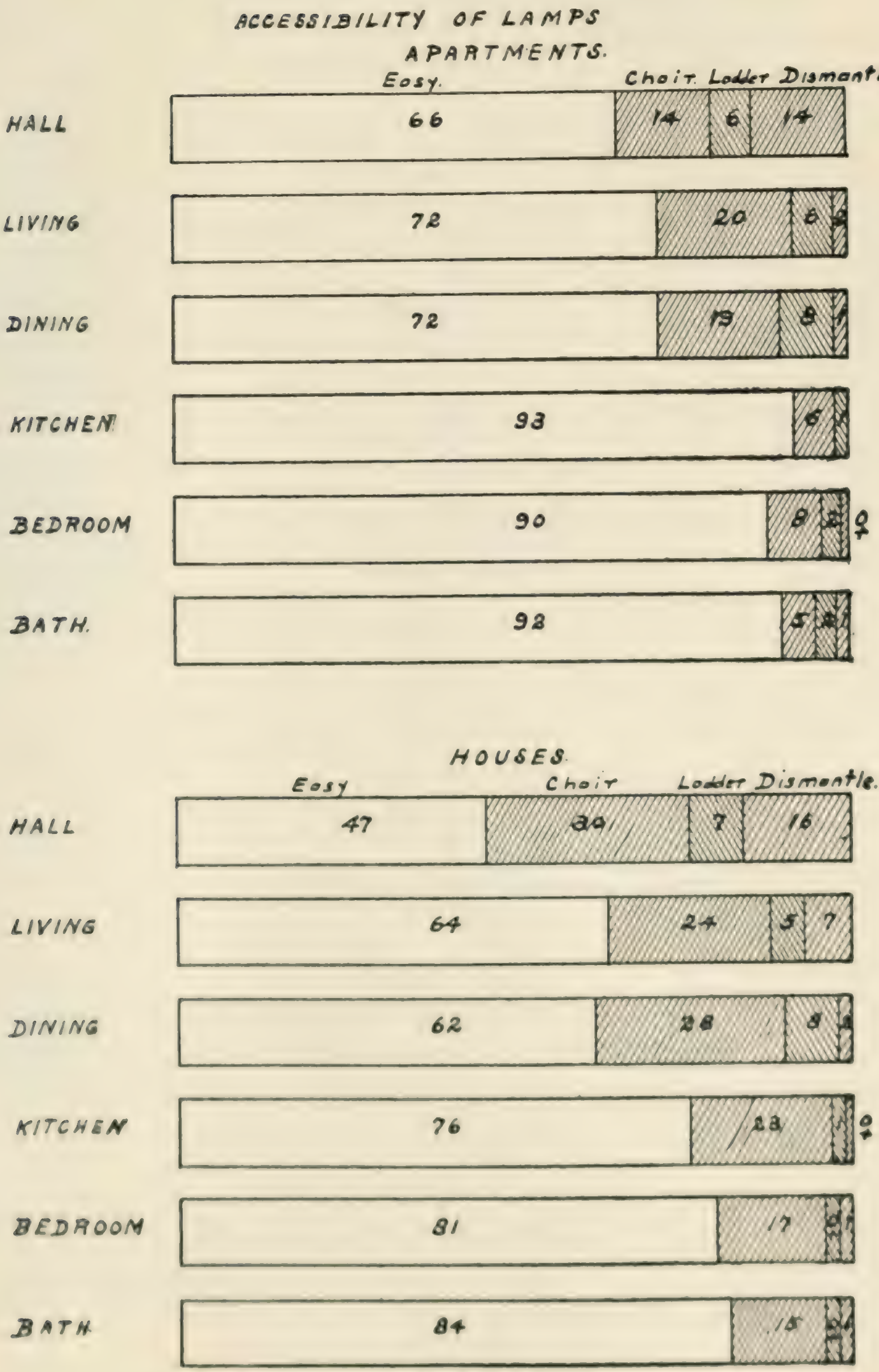

ACCESSIBILITY OF LAMPS
APARTMENTS.
Easy. Chair. Ladder Dismantle.
HALL 66 14 6 14
LIVING 72 20 6
DINING 72 19 8 1
KITCHEN 93 6
BEDROOM 90 8 2 0
BATH. 92 5 2
HOUSES
Easy Chair Ladder Dismantle.
HALL 47 30 7 16
LIVING 64 24 5 7
DINING 62 28 8
KITCHEN 76 23 0
BEDROOM 81 17
BATH 84 15

Fig. 5.

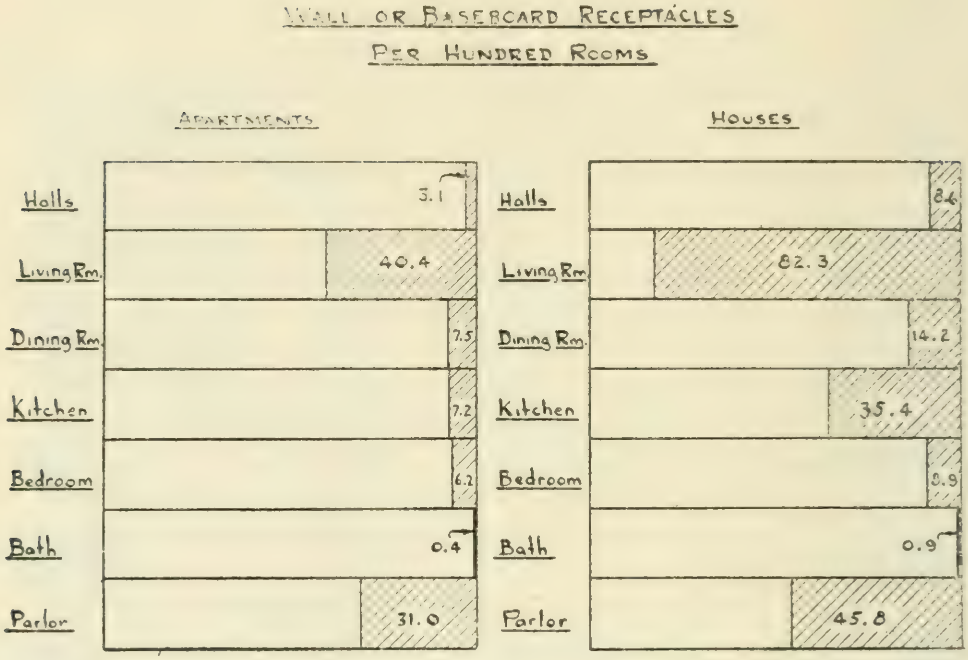

Wall or Baseboard Receptacles
Per Hundred Rooms
Apartments
Houses
Halls
Living Rm.
Dining Rm.
Kitchen
Bedroom
Bath
Parlor
3.1
40.4
7.5
7.2
6.2
0.4
31.0
82.3
14.2
35.4
0.9
45.8

Fig. 6.

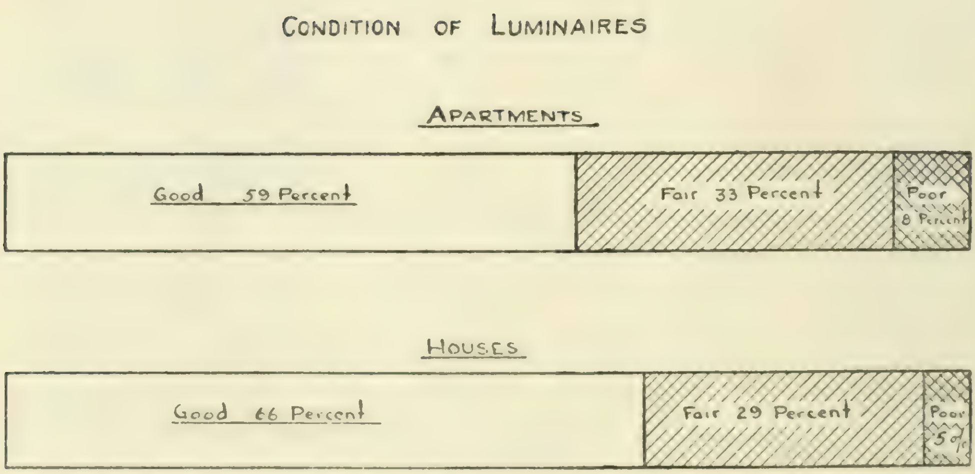

Condition of Luminaires
Apartments
Good 59 Percent
Fair 33 Percent
Poor 8 Percent
Houses
Good 66 Percent
Fair 29 Percent
Poor 5%

Fig. 7.

Condition of Luminaires (Figure 7).—Undoubtedly the judgment of the inspectors has something to do with a somewhat large variation which appears between the average values for different cities. The average of all surveys, however, indicates that approximately 63 per cent are in good condition, 30 per cent in fair condition, and the rest poor. This refers only to mechanical excellence. "Poor condition" indicates loose sockets, swinging chandeliers, etc. "Fair condition" indicates that luminaires have some minor defect, such as dropped canopy, bent piping, etc., which may or may not detract from the usefulness, but debars the luminaire from the mechanically good class. The difference in condition between the luminaires in apartments and houses is probably the natural variation occasioned by the number of houses which are owned by the tenants and which may be expected to be kept in better repair.

TABLE VII.

CLEANING PERIODS OF LUMINAIRES PER YEAR

	Apartments	Houses
	Cleanings per yr.	Cleanings per yr
High city	12.0	6.4
Average	8.3	5.3
Low city	2.3	4.2

Average cleaning periods as reported for the various cities seem to be in fairly close agreement, except that values found for two of the companies in the same city in the apartment survey are very much higher than all the others, although they check each other, which indicates that a different condition obtains in that city. The reason for this is obscure. The general indication, however, is that a doubling of the cleaning periods would probably make for more satisfactory lighting.

TABLE VIII.

SPARE LAMPS

	Per cent residences having spare lamps	Number of spare lamps per residence having lamps
	APARTMENTS	
High city	34.6	4.7
Average	12.8	3.3
Low city	2.0	1.0
	HOUSES	
High city	34.2	7.3
Average	21.0	4.4
Low city	13.0	1.5

A variation of from 2 to 35 per cent is found in the percentage of residences having spare lamps. The variation between different cities is probably due to the variation in lamp supply methods. The significant indication of the table, however, is that most householders are not at present provided with an emergency supply of lamps.

DATA FOR LIVING ROOMS

Classification of Luminaires (Figure 8 and tables).—The diagram shown illustrates the luminaires which are in constant use. For instance, the 9.3 per cent of living rooms in apartments which are illuminated by table portables probably have installed some form of chandelier or wall brackets, but in all cases our inspectors were informed that the table portable was the only unit in regular use. If a chandelier was used usually with the portable, the living room was classed with the group called "Center Fixture with Portable." It is interesting to note that the shower is the most popular luminaire in apartments, and that in houses the table portable is the largest single factor, the shower being used only half as generally as in apartments. It is possible that the inexpensiveness of the shower is one cause of its popularity.

Portable Connected to Luminaire (Figure 9).—In approximately one-third of the living rooms, both apartments and houses, a portable lamp is connected to the fixture. This may be the result of several different causes.

TABLE IX.

LIVING ROOM LIGHTING EQUIPMENT IN APARTMENTS—ALL CITIES COMBINED

PERCENTAGE BASIS

Kind of fixtures	Total per cent	Lamps visible from below			Average no. sockets per luminaire		Plug and cord to portable			Combination G. & E.		
		Yes	No	?			Yes	No	?	Yes	No	?
Shower	29.5	75.3	22.3	2.4	4.1		13.1	84.5	2.4	5.5	54.3	40.2
Chandelier	22.3	72.7	26.8	0.5	3.7		22.7	70.0	7.3	31.4	29.5	39.1
Bowl	4.6	2.2	97.8	—	3.5		8.9	88.9	2.2	—	73.3	26.7
Table portable	9.3	27.2	69.5	3.3	2.4		43.5	27.2	29.3	—	81.5	18.5
Floor lamp	2.9	24.1	58.7	17.2	1.6		37.9	44.9	17.2	—	100.0	—
Wall brackets	0.7	57.2	28.6	14.2	3.3		28.6	71.4	—	14.2	28.6	57.2
					Portable	Fixture						
Chandelier and bowl or shower with portable	25.4	54.8	44.3	7.9	3.7	1.8	53.2	45.6	1.2	16.0	74.0	10.0
Chandelier, bowl or shower with portable and brackets	5.2	47.0	53.0	—	3.9	1.5	33.3	66.7	—	5.9	92.1	2.0
Border or cove lighting	0.1	—	100.0	—	17		—	—	100.0	—	100.0	—
Total or average	98.6	58.5	39.6	1.9	—		29.9	64.0	6.1	13.1	60.3	26.6

TABLE X.

LIVING ROOM LIGHTING EQUIPMENT IN HOUSES—ALL CITIES COMBINED

PERCENTAGE BASIS

Kind of Fixtures	Total per cent	Lamps visible from below Yes	Lamps visible from below No	Lamps visible from below ?	Average no. sockets per luminaire		Plug and cord to portable Yes	Plug and cord to portable No	Plug and cord to portable ?	Combination G. & E. Yes	Combination G. & E. No	Combination G. & E. ?
Shower	16.7	42.7	56.2	1.1	4.7		22.5	77.5	—	3.4	62.9	33.7
Chandelier	15.7	52.4	44.0	3.6	4.7		21.4	76.2	2.4	15.5	32.1	52.4
Bowl	4.3	4.3	95.7	—	4.2		8.7	91.3	—	—	78.2	21.8
Table portable	33.0	35.2	59.7	5.1	2.5		50.0	47.2	2.8	—	90.3	9.7
Floor lamp	12.0	32.8	67.2	—	3.2		35.9	56.3	7.8	—	98.4	1.6
Wall brackets	0.7	25.0	75.0	—	2.9		—	100.0	—	—	75.0	25.0
					Fixture	Portable						
Bowl or shower with portable	15.4	50.0	47.5	2.5	3.9	2.0	46.3	53.7	—	4.9	57.3	37.8
Chandelier, bowl or shower with portable and bracket	2.2	25.0	75.0	—	3.3	1.4	25.0	75.0	—	—	100.0	—
Total	534	39.5	57.7	2.8	—	—	36.0	61.8	2.2	3.7	72.1	24.2

Classification of Luminaires
Living Rooms Only

	Apartments	Houses
Border Lighting	0.1	0.0
Center Fixture with Portable and Bracket	5.2	2.2
Centre Fixture with Portable	25.4	15.4
Wall Bracket	0.7	0.7
Floor Lamp	2.9	12.0
Table Portable	9.3	33.0
Bowl	4.6	4.3
Chandelier	22.3	15.7
Shower	29.5	16.7

Fig. 8.

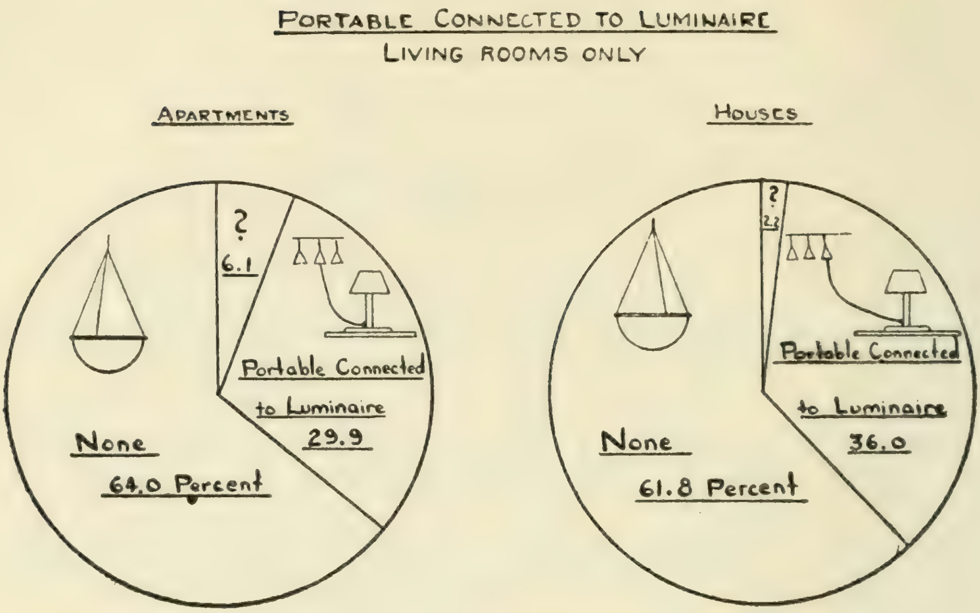

PORTABLE CONNECTED TO LUMINAIRE
LIVING ROOMS ONLY
APARTMENTS
?
6.1
Portable Connected
to Luminaire
29.9
None
64.0 Percent
HOUSES
?
2.3
Portable Connected
to Luminaire
36.0
None
61.8 Percent

Fig. 9.

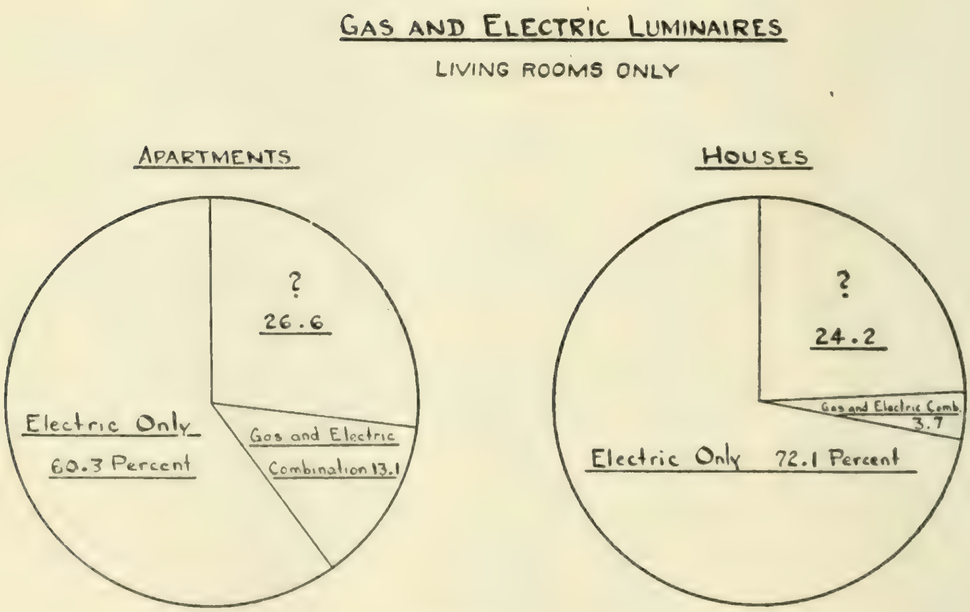

GAS AND ELECTRIC LUMINAIRES
LIVING ROOMS ONLY
APARTMENTS
?
26.6
Electric Only
60.3 Percent
Gas and Electric
Combination 13.1
HOUSES
?
24.2
Gas and Electric Comb.
3.7
Electric Only 72.1 Percent

Fig. 10.

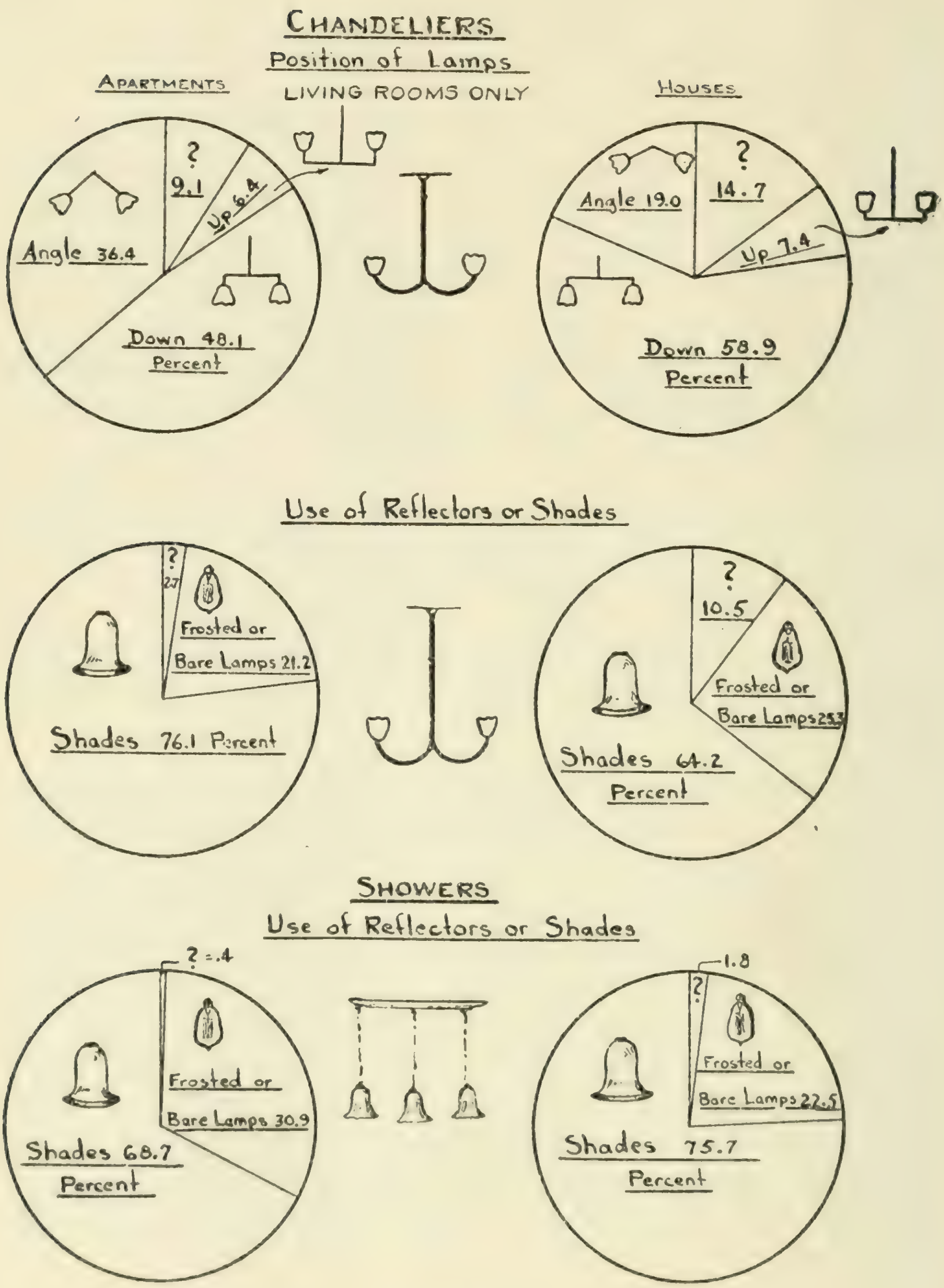
1. First and probably most important is the unsatisfactory quality of the installed center fixture. In a great many cases this was a poorly designed shower. In a rented home, the land lord probably will not improve the original installation and feels that he has done everything that is required of him in placing a chandelier in the center of the room, and therefore the tenant in improving lighting conditions at his own expense, has the choice of installing a new fixture, which properly designed for the room might cost him between $50 and $60 installed, and which might revert to the landlord upon his giving up the premises, or of purchasing a table lamp, which will give him the cosy warm feeling which he craves, at about half the price, with no installation cost. There is no question of his right to take such a lamp with him to a new home.

2. The second cause is probably that many of us have childhood associations with the central kerosene table lamp, and unconsciously choose its electrical successor from habit.

3. Undoubtedly the question of style plays a large part, as portable lamps are being advertised largely and sold through many agencies.

Percentage of Combination Gas and Electric Luminaires (Figure 10).—It must be remembered in discussing this chart that these surveys were all made in houses connected to the lines of electric central station companies. This chart is in no sense a comparison of residences illuminated by gas vs. those illuminated by electric light. It does indicate the proportion of residences lighted by electricity which have, in addition, facilities for gas lighting. It is probable that this is rapidly decreasing as the combination fixtures, as indicated in some of the lantern slides, are of an older type. This proportion will probably become smaller as modern luminaires are adopted. Modern illuminants, both gas and electric, do not lend themeslves to combination treatment.

Position of Lamps and Use of Reflectors (Figure 11).—The position of the lamp in the living room fixtures is of greatest significance only in the case of chandeliers, and in these it is found that more than half are designed for downward burning.



CHANDELIERS
Position of Lamps
LIVING ROOMS ONLY
APARTMENTS
HOUSES
?
9.1
Up 6.4
Angle 36.4
Down 48.1
Percent
?
14.7
Angle 19.0
Up 7.4
Down 58.9
Percent
Use of Reflectors or Shades
?
2.7
Frosted or
Bare Lamps 21.2
Shades 76.1 Percent
?
10.5
Frosted or
Bare Lamps 25.3
Shades 64.2
Percent
SHOWERS
Use of Reflectors or Shades
? = .4
Frosted or
Bare Lamps 30.9
Shades 68.7
Percent
1.8
?
Frosted or
Bare Lamps 22.5
Shades 75.7
Percent

Fig. 11.

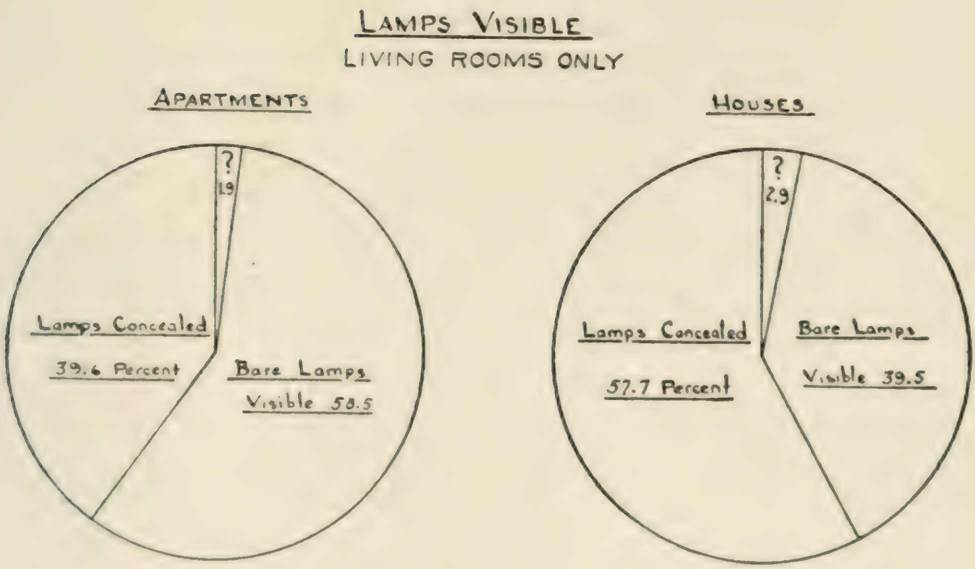


Fig. 12.

It is probable many new luminaires will be manufactured with the lamps in this position, and that the chandeliers which are now found installed, having lamps at an angle, are more or less obsolete types. It is surprising to find, however, both in showers and in chandeliers, that in about 25 per cent of the cases shades and reflectors are dispensed with. It is probable that in all such cases the luminaires are designed originally for frosted lamps, but it is found in the substitution of new lamps for burnouts, that it is not always easy for the householder to procure the proper frosted lamp, and therefore clear lamps are used. It is unfortunate that a tally was not made of the frosted and clear lamps in our data. Something as to lamp exposure will be found in the next figure.

Visibility of Bare Lamps (Figure 12).— Inspectors were instructed to look at each lighting unit in living rooms from a number of the most used portions of the room. In about one-half of the cases bare lamps were found to be within the line of vision,

the percentage being about 60 in apartments and 40 in houses. This is a very important finding, as it indicates that in our campaign of education we have not as yet persuaded the householder of the objectionable character of glaring sources.

CONCLUSIONS

In summing up the data which have been presented, we find that the average central station customer lives in a dwelling of nine enclosed spaces (probably five rooms, bath, two halls and a closet) of about 1,000 square feet in area. He uses about sixteen incandescent lamps of the 25 to 60-watt sizes. There are three to four persons in the family (average 3.6). The rooms vary in size from 45 square feet to 190 square feet. The rooms in general are illuminated in spots, but the watts per square foot indicate that the general illumination is low, although the most used portions of the rooms are fairly well illuminated. The customer selects home decorations from the viewpoint of custom or appearance and pays relatively little attention to their influence upon illumination. He has far too few convenience outlets and therefore uses drop cords for table lamps and appliances. He needs 4 per cent more lamps at once to replace outages and has not been taught the value of keeping spare lamps on hand. He has abandoned 11 per cent of his original installation as unsatisfactory or superfluous.

Owing to height or inconvenience, he has trouble in replacing 25 per cent of his bulbs. He needs to be taught the value of light reflecting decorations and that his lighting appliances need to be cleaned as often as his windows. And last, and most important, he is unadvised of the advances in lighting practice of the past few years, and of his own need of proper modern lighting equipment, as in the majority of cases the luminaires found are of the same period as the house. A rough estimate would indicate that less than 10 per cent of the luminaires reflect modern engineering thought. This is further emphasized by the fact that in living rooms 50 per cent of the lamps are so placed that bare lamps are in the line of vision, and in 33 per cent of these rooms portable lamps have been introduced to improve the original installation.

Here then, is the problem for this Society. There is available in the Society the ability, the talent and the will to better this condition. It is not being improved because the average man handling lighting products, be he manufacturer, dealer, architect, contractor, or central station representative, has not been sufficiently impressed with the need for good lighting. A big opportunity for service will be lost if the channel is not soon found through which the residence consumer may be impressed with the need for better lighting conditions and the need for proper advice in securing them.

DISCUSSION

The papers by Messrs. Macdonald and Luckiesh were discussed together. See page 531.

A SURVEY OF RESIDENCE LIGHTING*

BY M. LUCKIESH**

SYNOPSIS: This paper is based upon the results of a detailed survey of lighting in the urban middle-class home. The results are averages of about 1,500 representative homes consisting of groups from a number of cities throughout this country. The average values obtained for the first 800 homes did not differ materially from the average values of the rest of the homes represented in the survey up to the present time. This indicates that the aggregate number is sufficient to be representative. The survey is being continued and extended to smaller towns and to the low-class home.

It was the aim of the survey to obtain a detailed view of the lighting and wiring conditions in the wired homes in order to show the deficiencies. This detailed view indicates the trends that campaigns for better lighting should take and also shows where those responsible for lighting have failed in the past. An elaborate survey-form was devised in such a manner that a member of the household could easily record the data requested. All forms on which there was an obvious error were completely discarded. These will be studied later in order to ascertain if possible the points with which the public is least familiar.

The survey reveals the influence of rental and of ownership on the wiring and lighting equipment. It shows that the average rented middle-class home consists of slightly under six rooms and the average "owned" home slightly more than seven rooms. The rented home is more deficient than the owned home in all details of wiring, wattage, fixtures, portables, convenience-outlets, etc.

The survey-form reveals the conditions in each room such as number of convenience-outlets, ceiling-fixtures, wall-brackets, portables, watts per socket, the type of fixture, the material of shades, etc. A group of low-class homes is compared with the average middle-class home.

A conservative wiring and lighting equipment was specified for the average middle-class home and this was compared with the average actual conditions. This comparison provided the degrees of saturation of various items of wiring and equipment in the middle-class home. All items excepting ceiling-fixtures are less, and most of them much less, than 50 per cent of what they should be if convenient, proper, and conservatively adequate lighting existed in the middle-class home of to-day. The deficiency in wiring is chiefly found in the cases of convenience-outlets, and outlets for brackets. The deficiency in lighting equipment is chiefly found in the cases of shades, wall-brackets and portables. In general the watts per socket should be increased somewhat but the chief need is the increase in the number of sockets. From 12 to 38 per cent of the wall-brackets, depending upon the room, were found without shades and from 7 to 21 per cent of the ceiling-fixtures had no shades.

*A paper presented at the Annual Convention of the Illuminating Engineering Society, Swampscott, Mass., Sept. 25-28, 1922.

**Director of Applied Science, Nela Research Laboratories, Nela Park, Cleveland, Ohio.

The situation may be summed up approximately as follows: one-half of the population of this country live in places larger than 2,500 inhabitants; only one-half the homes within easy reach of electric service are wired; one-half the wired homes are rented; the middle-class home is less than "half-lighted;" and the low-class homes are only half as well lighted as the middle-class homes.

INTRODUCTION

It does not require extensive observations to conclude that a large percentage of homes is inadequately and improperly illuminated and that the average householder is unconscious of many of the possibilities of modern lighting. If adequate and proper lighting is to be introduced into the home, a large field at the present time is represented by the eight million houses that are wired for electricity. It is easy to design the wiring and lighting for a house or an apartment to be built but to convince the owner is another matter. That the public has not been convinced of the importance and possibilities of lighting is proved by the lighting conditions in the homes to-day. It is known in a general way that residence lighting is deficient and defective, but little is known of the details. To obtain detailed information of existing conditions a survey was planned.

In order to get the most from a survey it appeared necessary to recognize the groups into which homes and householders can be classified. For this purpose some general data are available. According to the census of 1920, 54 per cent of the population of this country lived in rented homes and approximately 50 per cent of the population lived in places larger than 2,500 inhabitants. Inasmuch as relatively few single houses are rented, it may be assumed that approximately one-half the population lives in apartments including the two-family houses. Further it may be assumed that approximately one-half the population is urban. Since a greater percentage of the homes reached by electric service are in the larger rather than in the smaller places, it is safe to state that the majority of the eight million wired homes are urban homes. From the standpoint of lighting, the renter and the householder who owns his own home present somewhat different problems. Similarly the apartment owner or landlord differs from the householder who owns his own home because the former is not as vitally interested in lighting as the one who lives with it and owns it. The urban householder also differs somewhat from the rural householder or one who lives in

a small town. Eventually it is hoped to have data which will apply to these various individuals.

A great deal of thought was given to devising a form which would be simple but would yield detailed information. The plan was to have the householder or a member of the household fill out the form, thus reducing the cost of the survey and making it possible to survey a greater number of homes. The form proved very satisfactory although many returns had to be discarded owing to obvious or suspected errors. These forms were sent to various persons in different cities, to large offices and factories employing largely what might be termed the "middle-class."

The primary aim of the first part of the survey was to obtain detailed information of the average conditions in the middle-class homes. It is difficult to define the so-called "middle-class" but it has been assumed to be a group larger than the "low-class" and the "high-class" groups of homes. In other words, the middle-class group is represented in offices and in factories employing the more intelligent workers. Special surveys are being conducted in small towns and in the low-class homes. In fact the survey is still progressing and it is the aim to continue it for some time. The data upon which this paper is based were obtained from analyses of detailed surveys of about 1,500 homes in a number of cities in various parts of the country. These are almost equally divided into "rented" and "owned" homes. Summaries of several smaller groups indicate a general similarity to the complete summary. The form used was 8½ inches by 14 inches and is reproduced in Figure 1 reduced in size. Four questions were asked and following these was a description of the types of ceiling-fixtures designated by letters. This was followed by letters indicating the material which shades or envelops the light-sources. A ruled form provided horizontal rows of spaces for recording the data for each room. Vertical columns were provided for ceiling-fixtures, portable lamps, and wall-brackets and data requested for each of these classes of fixtures for each room. These data pertained to the number and type of fixtures, the material of shade, total number of sockets, and total wattage. A column was also provided for the number of convenience outlets in each room and one for floor dimensions.

A SURVEY OF RESIDENCE LIGHTING

The following questionnaire is submitted for the purpose of obtaining data which will aid in advancing the cause of good lighting. Will you please aid us in this nation-wide survey by furnishing data pertaining to your residence? These data will be used only for the purpose of summarizing the average lighting conditions of the present time.

QUESTIONNAIRE

1. Do you live in a "single" house? Ans. ....
2. Do you own your home? Ans. ....
3. Is your home wired for electricity? Ans. ....
4. How many rooms (including bath and sun room) in your home? Ans. ....
5. Please fill out the table, using the symbols according to the following instructions.

The type of ceiling fixtures is to be designated by the following symbols:

B .... **Bowl**—A fixture consisting of a bowl usually hung on chains suspended from the ceiling.

S .... **Shower**—A fixture suspended from the ceiling in which a number of incandescent lamps are hung in a downward position.

BS .... **Bowl and Shower** combined in a single fixture.

R .... **Rosette**—A fixture consisting of a plate attached to the ceiling on which is mounted one or more rosettes, each containing a socket.

C .... **Candelabra**—A fixture suspended from the ceiling in which a number of incandescent lamps are mounted in an upright position as imitation candles.

D .... **Dome**—A fixture consisting of a large shade suspended from the ceiling with a wide opening at the bottom directing light downward. This unit is the reverse of a bowl.

BL .... **Ball**—A fixture of totally enclosing material (regardless of shape) which is hung at the ceiling.

DC .... **Drop-cord**—A fixture consisting of a cord suspended from the ceiling with one socket attached.

The material which shades or envelops the light sources is to be designated by the following symbols:

G .... Glassware
S .... Silk or other woven fabric
P .... Parchment
M .... Metal
N .... No shade

A **Bracket** is a fixture fastened to the wall.

A **Convenience Outlet** is an outlet in the baseboard, wall or floor used to connect conveniences such as portable lamps or electric appliances.

	CEILING FIXTURES					PORTABLE LAMPS				BRACKETS				No. of Convenience Outlets	Approximate Floor Dimensions in Feet
	No. of Fixtures	Type of Fixtures	Material of Shade	Total No. of Sockets	Total Wattage (Lamps)	No. of Portables	Material of Shade	Total No. of Sockets	Total Wattage (Lamps)	No. of Brackets	Material of Shade	Total No. of Sockets	Total Wattage (Lamps)		
Living Room															
Sun Room															
Study															
Dining Room															
Kitchen															
Basement															
Porch															
Entrance Hall															
Upstairs Hall															
Bedroom															
Bedroom															
Bedroom															
Bath															

Fig. 1.—Reproduced from the original survey form which was 8½ inches by 14 inches.

THE NUMBER OF ROOMS

The number of rented homes practically equalled the number of homes occupied by the owner. It is interesting to study the relative distribution of the homes of different sizes. In Figure 2 are plotted the relative number of houses of various sizes

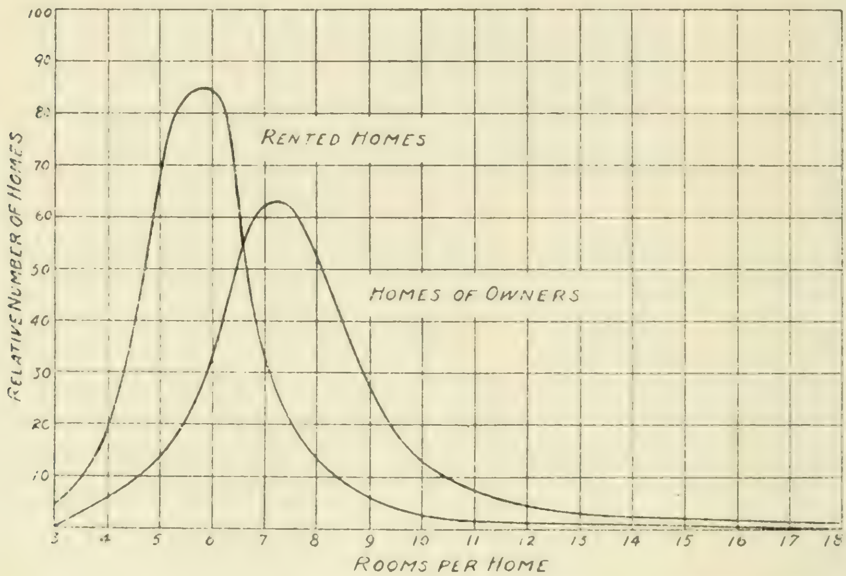


Fig. 2.—The distribution of equal groups of "rented" and "owned" homes according to number of rooms.

for equal groups of "rented" and "owned" homes. In other words the areas under the two curves should be equal. It is seen that the maximum is at about 5.8 rooms per home for the rented group. There is somewhat more "spread" in the "owned" group but there is a definite maximum in the region of 7.3 rooms per home.

In Figure 3 are plotted the percentages of "rented" and of "owned" homes of the total of each size. It is interesting to note the transition from predominantly rented homes to predominantly owned homes. This takes place largely in passing from the six-room to the seven-room home. Of the homes having six rooms or less, more than 80 per cent are rented; of those having eight rooms or better, more than 80 per cent are occupied by the owner.

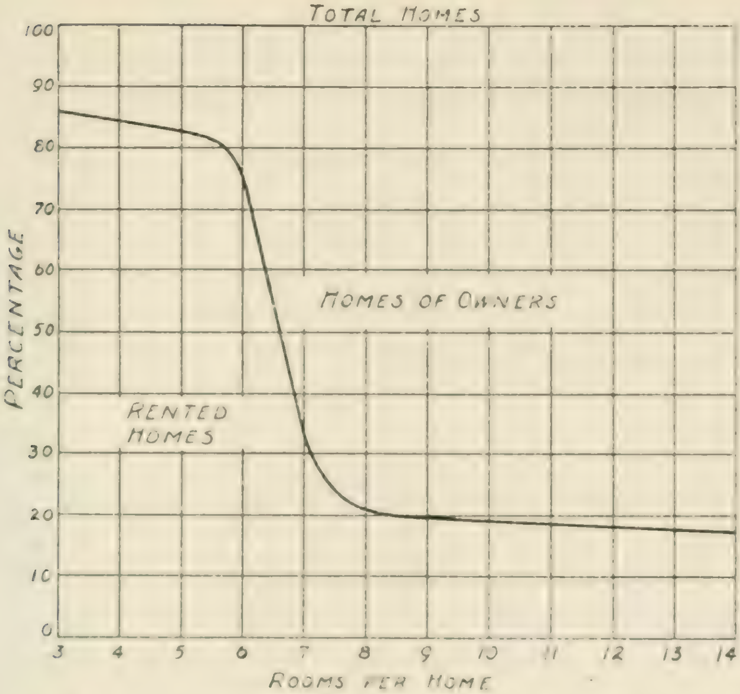


Fig. 3.—Percentages of "rented" and of "owned" homes of various sizes.

THE "CONSERVATIVE IDEAL" AVERAGE MIDDLE-CLASS HOME

The survey not only yields the details of wiring and of lighting but provides an average home as to size or number of rooms. This is made use of by designing conservative but adequate and proper wiring and lighting for this theoretical average home and ascertaining the difference between the actual conditions and those in the "conservative ideal" home. The average home may be wired and equipped in various ways and in the following paragraphs general descriptions and summaries are presented. These form a basis for computing the standings of various items considered in the survey. No detailed description of the fixtures and portables are presented for these are assumed to be equipped with proper shades, etc., to satisfy the requirements of good lighting.

Living room

General lighting from a shower, or from "direct-indirect" portables, could utilize 200 watts. A table-lamp, a floor-lamp, a small piano or desk lamp, and two small decorative portables can account for 340 watts. This is a total of 540 watts all of which,

of course, would seldom be used at one time. If decorative brackets were used the general lighting or decorative portables might be reduced accordingly. Three convenience outlets are specified.

Dining-room

In the case of a shower, lamps aggregating 150 to 200 watts in deep dense shades could provide general lighting and from 30 to 100 watts in decorative portables or brackets. A total of 230 watts is assumed to be desirable. One convenience outlet is specified.

Kitchen

A 100-watt lamp in the central fixture is assumed to be a desirable average. This would be a 150-watt if a "daylight" lamp is used. Two auxiliary brackets or other sockets would easily account for 80 watts. It appears safe to assume a total of 180 watts as desirable. One convenience outlet is specified.

Bedroom

A central fixture using 50 watts, two brackets or dresser lamps using 50 watts, and a bed lamp of 40 watts makes an aggregate of 140 watts. This wattage may easily be distributed in two brackets and a portable without considering a ceiling-fixture. One convenience outlet is specified in each of three bedrooms.

Bathroom

One bracket on each side of the mirror and each containing a 50-watt lamp accounts for 100 watts. One convenience outlet is specified.

Basement

Assuming a 100-watt lamp or a 150-watt "daylight" lamp over the laundry trays and four other outlets distributed in locker, over work-bench, near heater, in coal bin, in toilet, etc., it is easy to account for a total of 300 watts.

Convenience outlets

A total of nine is assumed, thus providing an average of one per room with two extra for the living-room.

Portables

A total of eight is assumed; these include the small decorative portables.

Wall-brackets

A total of nine is assumed; these can easily be accounted for from a purely utilitarian standpoint without considering any decorative brackets in the living or dining-room. Two in each bedroom, two in the bathroom, and one in the kitchen account for nine.

Ceiling-fixtures

An average of one per room is quite, if not more than sufficient.

Total wattage

A total of 1,770 watts in these various rooms is assumed.

Summary

It should be noted that only the rooms included in the foregoing paragraphs are considered in this paper. Data pertaining to hallways, porches, etc., have been obtained but are generally excluded in order to simplify the presentation. In other words only the living-room, dining-room, kitchen, bedrooms, bathroom, and basement enter into the values presented herewith unless otherwise stated.

MATERIAL OF SHADES

The material which shades or envelopes the light-sources is designated in the survey as follows:

G—*Glassware*, S—*Silk or other woven fabric*, P—*Parchment*, M—*Metal*, N—*No shade*.

No questions were asked as to the characteristics of the glassware, that is, whether clear, frosted, highly diffusing, etc., because of the risk of making the survey-form too complex. Furthermore it was thought that the householder would not be able to answer these questions satisfactorily. It is a common observation that much of the glassware in existence is sand-blasted or etched crystal glass. These are not sufficiently diffusing to provide proper lighting with modern electric lamps. It is also known that many of the shades are not deep enough or of proper shape. The data obtained pertaining to types of fixtures, number of sockets, etc., is of interest in considering the material of shades.

The percentages of the various materials in use for shading, reflecting, and diffusing are presented in Table I for the various classes of fixtures, in the various rooms. The horizontal rows of percentages should equal 100.

TABLE I.—MATERIALS IN USE FOR SHADING, REFLECTING OR DIFFUSING LIGHT IN THE MIDDLE-CLASS HOME.

	Percentage				
	Glass	Silk	Parchment	Metal	None
Living-room					
Ceiling-fixtures	85	6	1	1	7
Wall-brackets	48	19	11	1	21
Portables	32	57	6	4	1
Dining-room					
Ceiling-fixtures	88	3	1	1	7
Wall-brackets	56	13	8	—	23
Portables	44	38	11	4	3
Kitchen					
Ceiling-fixtures	76	—	—	3	21
Wall-brackets	60	1	—	1	38
Bed-rooms					
Ceiling-fixtures	89	1	—	—	10
Wall-brackets	77	10	1	—	12
Portables	35	46	8	10	1
Bath-room					
Ceiling-fixtures	80	—	—	1	19
Wall-brackets	85	—	—	1	14
Totals					
Basement sockets	10	—	—	3	87
Ceiling-fixtures	85	2	—	1	12
Wall-brackets	73	7	3	—	17
Portables	34	52	7	6	1

It will be noted that 12 per cent of the ceiling-fixtures and 17 per cent of the wall-brackets have no shades. The candelabra and other fixtures designed for round-bulb lamps are responsible for much of these percentages. There is missionary work to be done in equipping these "round-bulb" fixtures with shades. There are holders available now for these fixtures which do not have holders attached. Some of these holders are held in place by screwing the lamp into the socket thus making it possible for anyone to

equip these fixtures with shades. The basement is also open for missionary work, especially in the case of sufficient and proper lighting for the laundry trays.

There is an appreciable percentage of all fixtures in all rooms not equipped with shades. Glass is the predominant material excepting in the case of portables. Here silk predominates.

CEILING FIXTURES

There is more or less confusion and indefiniteness in the use of names of fixtures. In connection with the Code of Luminaire Design which is in preparation this matter is being given consideration. For the purpose of the survey it was necessary to adopt simple definitions but not too many of them. Furthermore knowing where the fixture was used, how many sockets it had, and the wattage of lamps it was easy to check up some of the types. The definitions used on the survey-form are presented herewith.

The lighting equipment is divided into three *classes* of fixtures, namely ceiling-fixtures, wall-brackets, and portables. These are then subdivided into *types* such as shower, etc.

The ceiling-fixtures are designated in the survey-form by their initials and are defined as follows:

B—*Bowl*—A fixture consisting of a bowl usually open at the top and hung from the ceiling.

S—*Shower*—A fixture, suspended from the ceiling, in which a number of incandescent lamps are hung in a downward position.

BS—*Bowl Shower*—A bowl and a shower combined in a single fixture.

C—*Candelabra*—A fixture suspended from the ceiling in which a number of incandescent lamps are mounted in an upright position on "imitation" candles.

DC—*Drop cord*—A fixture consisting usually of cord suspended from the ceiling with one socket attached.

R—*Rosette*—A fixture consisting of a plate attached to the ceiling on which is mounted one or more collars or rosettes each containing a socket.

BL—*Ball*—A fixture of totally enclosing glass or other material, regardless of shape, which is hung at the ceiling.

D—*Dome*—A fixture consisting of a large shade, suspended from the ceiling, with a wide opening at the bottom which emits light downward. This unit is the reverse of a bowl.

The percentages of various types of ceiling-fixtures found in the various rooms of the urban middle-class home are presented in Table II. These data show the tendencies of the past. We know from dealers' stocks what the present tendencies are.

TABLE II.—VARIOUS TYPES OF CEILING-FIXTURES IN THE VARIOUS ROOMS OF THE MIDDLE-CLASS HOME.

Classification	Percentages				
	Living-room	Dining-room	Kitchen	Bed-room	Bath
Bowl	16	21	3	10	4
Shower	58	42	6	23	3
Bowl-shower	11	12	—	—	—
Candelabra	3	7	—	—	—
Drop-cord	3	4	71	46	63
Rosette	7	4	10	15	18
Ball	1	1	3	5	11
Dome	1	9	7	1	1
	100	100	100	100	100

The average number of ceiling-fixtures, the average number of sockets per fixture, and the average watts per socket, for the various rooms are presented in Table III.

TABLE III.—CEILING-FIXTURES IN THE MIDDLE-CLASS HOME.

Type of Room	Fixtures per room	Sockets per fixture	Watts per socket
Living-room	1.0	2.8	41
Dining-room	1.0	3.4	40
Kitchen	1.1	1.1	59
Bedroom	0.8	1.3	43
Bathroom	0.5	1.0	51
Average	0.88	1.92	47

The average number of ceiling-fixtures per home is 5.4.

It is seen that there is an average of nearly one ceiling-fixture per room. This is as many as necessary for satisfactory lighting. Many of these are antiquated and should be replaced by modern fixtures but the rehabilitation of these old fixtures can be accomplished in many cases by installing new shades. It is interesting to note the predominance of the multi-socket fixture in

living and dining-rooms. The dome, if well designed, is one of the best fixtures for illuminating the dining-table, still it is used in only nine per cent of the dining-rooms. In some other rooms a type of fixture is used which was classified as a dome.

WALL-BRACKETS

There are many excellent uses for wall-brackets such as flanking mirrors in bedrooms and bathrooms. Brackets are also useful in the kitchen. Data pertaining to brackets are presented in Table IV from which it is seen that there is an average of only 0.37 bracket per room and only 2.6 brackets per home. Wall-brackets are not sufficiently used in bedrooms, bathrooms, and kitchens to meet the requirements of adequate and proper lighting. Allowing nine wall-brackets in the "conservative ideal" average home it is seen that this item is 29 per cent of saturation.

TABLE IV.—WALL-BRACKETS IN THE VARIOUS ROOMS OF THE MIDDLE-CLASS HOME.

Type of room	Fixtures per room	Sockets per fixture	Watts per socket
Living-room	0.40	1.2	34
Dining-room	0.21	1.3	31
Kitchen	0.17	1.0	35
Bed-room	0.45	1.1	40
Bath-room	0.63	1.0	45
Average	0.37	1.12	37

PORTABLE LAMPS

The portable lamp has many advantages in residence lighting as well as many applications. If properly designed for each purpose it can go far toward solving most of the lighting problems in the home. Its decorative value and its portability are preeminent characteristics. It represents the best solution of lighting problems for the renter in many cases. Of course it requires a convenience outlet and these are far too rare. However, it is relatively easy to install convenience outlets and the cost of a convenience outlet is less than that of a fixture. The landlord should be more easily persuaded to supply such outlets in the inadequately wired and illuminated apartment than to add more fixtures. Furthermore a single convenience outlet can be made a distribution center for several portables. From every angle the portable lamp has many advantages and it appears that its

present popularity will greatly increase. In fact if the manufacturer would supply portable lamps and portable brackets each properly designed for a definite lighting purpose, residence wiring and lighting could be solved largely by convenience outlets and portables respectively. In Table V data pertaining to portable lamps are presented.

TABLE V.—PORTABLE LAMPS IN THE MIDDLE-CLASS HOME.

Type of room	Portables per room	Sockets per portable	Watts per socket
Living-room	0.95	1.7	42
Dining-room	0.12	1.4	37
Bed-room	0.14	1.1	40
Average	0.40	1.4	40

An average of 1.6 portables per home is found in the middle-class home. In the "conservative ideal" average home eight portables, including the small decorative ones, have been provided. This indicates 20 per cent saturation.

CONVENIENCE OUTLETS

One of the most deplorable phases of the wiring of homes is the paucity of convenience outlets. When it is considered that, besides providing for the use of portables, convenience outlets extend their usefulness to the many electric appliances, it appears that there should be at least one in each room and at least two or three in the living-room. In the "modern electric homes" of average size as many as forty such outlets have been provided. In the "conservative ideal" average home nine convenience outlets have been allowed. The survey of the middle-class home reveals an average of 2.5 convenience outlets, therefore in terms of the "conservative ideal" this item is only 28 per cent of saturation.

In Figure 4 are shown the average number of convenience outlets per home and per room for homes of various sizes.

It is seen that the number of convenience outlets increases directly with the size but the number per room reaches a fairly steady value for sizes greater than the average home. Of the total number of convenience outlets; 71 per cent were found in homes having from six to nine rooms, and 83 per cent in homes

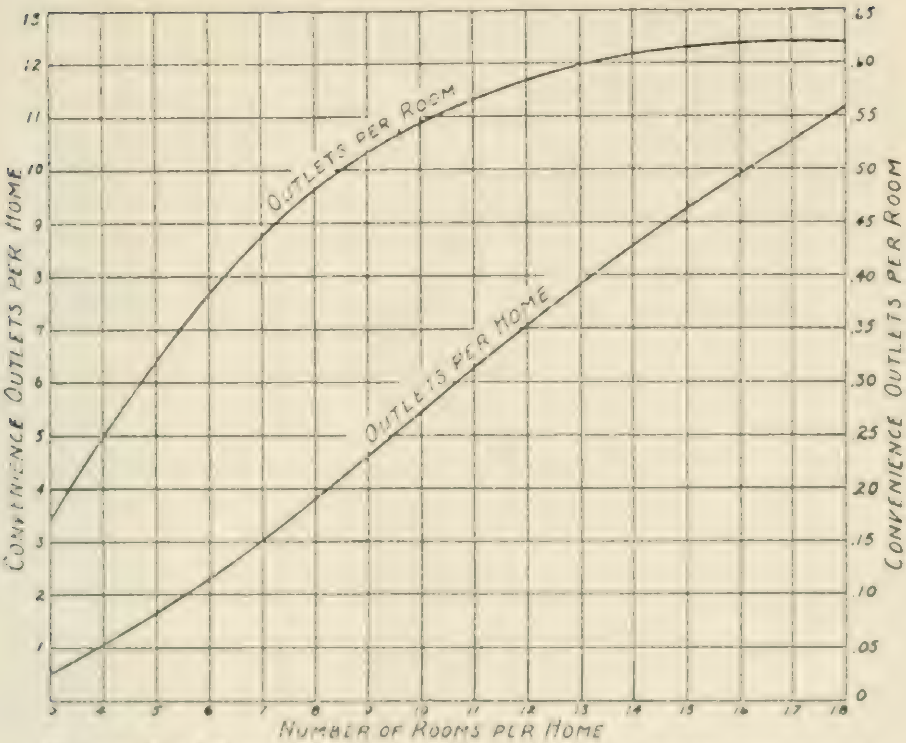


Fig. 4.—The influence of size of home on number of convenience outlets.

having from five to ten rooms. Of course this is largely due to the fact that most of the homes are found to be within these ranges.

WATTAGE

The average watts per socket is in general fairly satisfactory. These are shown in Tables III, IV, and V. The wattage in certain sockets such as in the kitchen, should be considerably increased. With the exception of the purely decorative brackets and portables the watts per socket should be somewhat increased to secure adequate lighting with proper diffusing shades, etc. But the total wattage of the average home falls far short of the total in the so-called "conservative ideal" average home. This is chiefly due to the inadequate number of sockets in the average home to provide convenient, adequate and proper lighting.

In Figure 5 are presented the average total wattage per home and per room for homes of various sizes.

The average total wattage of lamps per home found in the middle-class homes is 863 watts, including hallways, etc. This is an average of all sizes of homes surveyed.

The average total wattage of lamps per home found in the

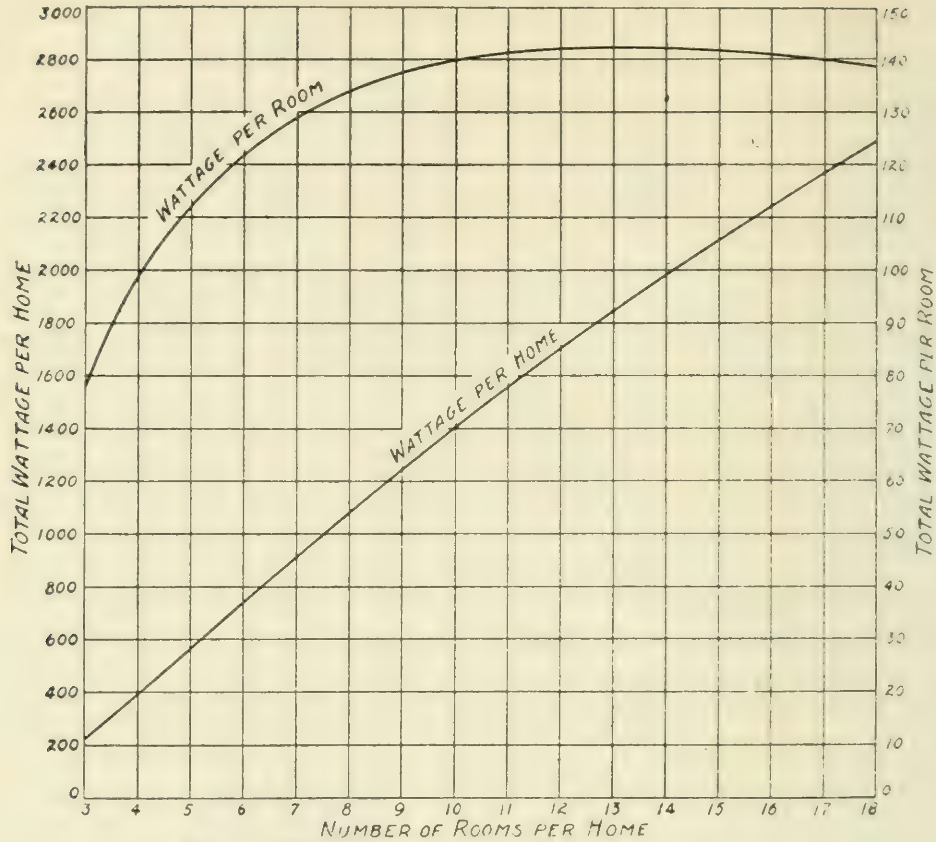


Fig. 5.—The influence of size of home on wattage.

rooms and basement, exclusive of hallways, etc., is 734 watts. This is an average of all sizes of homes surveyed. The average wattage per socket in these rooms is 42.3 watts.

The total wattage allowed in the rooms and basement of the "conservative ideal" seven-room home is 1,770 watts. From the data obtained it is found that the average total wattage per home, corrected to a seven-room house in order to be comparable with the wattage of the "conservative ideal," is 812 watts. Therefore by dividing 812 by 1,770 it is found that the average wattage per home is 46 per cent of that required for adequate and proper lighting as represented in the "conservative ideal" home.

This does not mean a similar increase in the consumption of energy for lighting. It is estimated that the energy consumption for lighting would be increased from 50 to 100 per cent if wiring and lighting equipment were brought up to the standard used in these computations.

The average total wattages in various rooms compared with the wattages allowed in the "conservative ideal" are presented in Table VI.

TABLE VI.—AVERAGE TOTAL WATTAGE IN VARIOUS ROOMS COMPARED WITH DESIRABLE TOTAL WATTAGE

Type of room	Actual wattage	Desirable wattage
Living-room	234	540
Dining-room	150	230
Kitchen	76	180
Bed-room	67	140
Bath-room	57	100
Basement	94	300

THE INFLUENCE OF OWNERSHIP

Approximately one-half of the homes reached by this survey at the present time were rented. The distributions as to size of rented and owned homes of equal number are shown in Figures 2 and 3. The details of this survey were summarized as to "rented" and "owned" homes for the purpose of comparing the two classes of homes. In the tables heretofore the data are the averages of the two classes taken as a single group. In this section some of the data are separated to show the difference between "rented" and "owned" homes. Some of the chief data are presented in Table VII for an equal number of rented and owned homes.

TABLE VII.—THE INFLUENCE OF OWNERSHIP ON WATTAGE, WIRING, ETC

Items	Rented homes	Owned homes	Ratio (per cent)
Total wattage of lamps per home	762.0	942.0	81
Percentage of total wattage per home	45.0	55.0	82
Convenience outlets	1.8	3.1	58
Percentage of total convenience outlets	37.0	63.0	59
Portables per home	1.5	1.7	88

The average total wattages per home in Table VII include hallways, etc.

Of course it should be noted that the most popular rented home has about one room less than the most popular size occupied by the owner. But this extra room in the latter case is not one of the chief rooms and therefore would not be likely to have a portable or a convenience outlet, considering the small number of such outlets. It would contribute some wattage to the total

but assuming that it contributed as much as an average bedroom or 67 watts, this would leave an average total wattage of the rented home 88 per cent of the average in the home occupied by the owner. From every angle the rented home is less adequately wired and equipped for lighting than the home occupied by the owner.

THE INFLUENCE OF COST

Although it is not difficult to obtain complete data pertaining to wiring and to lighting equipment, there are obvious difficulties in obtaining the cost data of houses and apartments. Furthermore these costs vary from year to year and in different parts of the country. From the data obtained it appears that the total wattage of lamps in a home, the average watts per room, and the number of convenience outlets increase somewhat with the cost of the single house for the smaller houses; that is, for houses having from three to seven rooms. However the number of rooms in a home appears to be a greater influence on these factors and, inasmuch as the cost of a house increases in general as the number of rooms increase, the influence of cost is included when the number of rooms is taken as a criterion. This provides a means of studying the influence of cost to some extent at least.

Data was obtained pertaining to the sizes of the rooms but it was found that these were so nearly uniform for the great majority of homes that there was little perceptible difference in the wiring and lighting equipment for rooms of the same character. For this reason the size of the room is omitted from this discussion.

NUMBER OF SOCKETS PER HOME

From such data as already presented it has been found that the average total number of sockets represented in the six rooms including living-room, dining-room, kitchen, bedroom, bathroom, and basement is seventeen. Adding to this two more bedrooms and we have twenty sockets exclusive of halls, porches, etc. Allowing four sockets for the other places we have a total of twenty-four sockets in the average middle-class home.

LOW-CLASS VS. MIDDLE-CLASS HOMES

The survey of low-class homes up to the present time includes only a single large group of about two hundred homes. These

were selected as being representative and were personally surveyed by co-workers of the author. The average data is compared with similar values obtained for the average middle-class home. About 90 per cent of this group of low-class homes had from five to seven rooms. In Table VIII are presented a comparison of total wattages per home for homes of various sizes. These values include the wattages in hallways, etc.

TABLE VIII.—AVERAGE TOTAL WATTAGE PER HOME IN LOW- AND MIDDLE-CLASS HOMES

Number of rooms	Total wattage		Ratio
	Low-class	Middle-class	
4	215	400	0.54
5	319	560	0.57
6	417	720	0.58
7	520	910	0.57
8	605	1080	0.56

It is seen that the average total wattage in the low-class homes is only about 56 per cent of that in the middle-class home of the same number of rooms. Considering the entire home including hallways, etc., the average total, 400 watts, of the low-class home is only 46 per cent of the average total, 863 watts, of the middle-class home. (See Table X).

Adding another bedroom with 39 watts (Table IX) to make the number of rooms of the low-class home comparable with the size of the middle-class home the total wattage for this low-class home of augmented size would be 439 watts or 51 per cent of the total wattage in the middle-class home of about the same number of rooms. The average wattages per room in the various rooms are presented in Table IX.

TABLE IX.—AVERAGE WATTAGE PER ROOM.

Type of room	Low-class	Middle-class
Living-room	104	234
Dining-room	83	150
Kitchen	58	76
Bed-room	39	67
Bath-room	38	57
Basement	52	94

The sum of the average wattages in these six places in the low-class home is 54 per cent of the similar summary in the middle-class home. This checks well with the ratios given in Table X which are for the average complete homes. The wattages per room are particularly valuable when considered in connection with the types of fixtures.

Another interesting comparison is that of the various classes of fixtures, portables ,and convenience outlets, wattages, etc. This is presented in Table X. In this case the values of portables, convenience outlets, and total wattages are for the entire home including hallways, etc.

TABLE X.—AVERAGE NUMBER OF FIXTURES, PORTABLES, WATTS AND VARIOUS OUTLETS IN THE LOWER- AND MIDDLE-CLASS HOMES.

Items	Low-class	Middle-class
Ceiling-fixtures	5.4	5.4
Wall-brackets	0.4	2.6
Portables per home	0.2	1.6
Sockets per basement	1.3	2.3
Convenience outlets per home	0.3	2.5
Total watts per home	400	863

It is seen that there is almost a total absence of brackets, portables and convenience outlets in this group of low-class homes. The lighting equipment consisted almost entirely of ceiling-fixtures. The number of sockets per fixture is approximately the same in these two classes of homes. In general it is concluded that the lower-class home is underlighted to even a greater degree than the middle-class home.

The percentages of fixtures in this low-class group of homes not having shades are as follows: kitchen ceiling-fixtures, 33 per cent; bedroom ceiling-fixtures, 26 per cent; bathroom ceiling-fixtures, 56 per cent; bathroom brackets, 56 per cent; basement sockets, 95 per cent. This represents a field for missionary work.

PER CENT SATURATION

Assuming that the survey has shown the average conditions of wiring and lighting in the middle-class home it is possible by using the values of the various items of wiring and lighting equipment in the "conservative ideal" home to compute the status of the various items or the per cent saturation. That the

data represents the average conditions in the middle-class home sufficiently closely for the present purpose is indicated by the inappreciable differences in the values of the various items in a summary of 800 homes as compared with a summary of the second similar group. Furthermore the survey has been conducted in about twenty cities throughout the country. Data on a few homes were obtained in many other places. Furthermore it appears that the lower-class home is even less adequately wired and lighted than the middle-class home. Therefore the percentages of saturation presented in Table XI should be conservative when applied to the eight million wired homes.

TABLE XI.—PERCENTAGE OF COMPLETE SATURATION OF VARIOUS PHASES OF THE AVERAGE MIDDLE-CLASS WIRED HOME.

Items	Per cent
Total wattage of lamps	46
Convenience outlets	28
Portable lamps	20
Wall-brackets	29
Ceiling-fixtures	100

CONCLUSIONS

Inasmuch as conclusions readily can be drawn from the data only a few will be pointed out here.

The most popular rented middle-class home has about six rooms. The most popular middle-class home occupied by the owner has about seven rooms. More than 80 per cent of the homes having six or less rooms are rented. More than 80 per cent of the homes having more than seven rooms are occupied by the owner. There is a very marked transition from predominantly rented to predominantly occupied by the owner in passing from the six-room to the seven-room home. The number of "rented" homes approximately equals the number of "owned" homes.

Glass predominates among the shades and diffusing media used on fixtures. Silk predominates on portables. Parchment is used only to a relatively small extent.

From 7 to 21 per cent of the ceiling-fixtures in various rooms of the middle-class home do not have shades. From 12 to 38 per cent of the wall-brackets in various rooms have no shades.

The use of ceiling-fixtures is as extensive as can be justified.

Wall-brackets are much less plentiful than they should be. An increase of 250 per cent in the number of utilitarian wall-brackets appears justifiable.

Considering their advantages the use of portable lamps is much less than it should be. An increase of 400 per cent appears justifiable.

The well-known scarcity of convenience outlets is verified. An increase of 250 per cent is justifiable.

The average total wattage per home is less than half what it should be to provide adequate and proper lighting. The average watts per socket is fairly satisfactory although it could be increased somewhat with justification. The sockets in the portables and wall-brackets which should be added to the average home in order to secure desirable lighting represent the desired increase in wattage to a large extent.

The average total watts and the average number of convenience outlets per home increases almost directly with the total number of rooms. This is true for the average watts per room and average number of convenience outlets per room for the smaller homes but these items appear to approach a constant value for the larger homes.

The wiring and lighting equipment in the rented home is marked by inferiority to that in the home occupied by the owner.

There is an average of about 24 sockets in the middle-class homes. The wiring and lighting equipment of the low-class home is very much inferior to that of the middle-class home. The deficiency is particularly marked by a nearly total absence of convenience outlets, portables, and wall-brackets, and by the large percentage of unshaded lamps. From 26 to 56 per cent of the fixtures, exclusive of the basement, were found to have no shades.

From the standpoint of an adequately and properly wired and equipped average middle-class home the average wired home to-day might be said to be less than "half lighted."

In this paper summaries of pertinent data yielded by the survey thus far have been presented. Data pertaining to many

other phases are already available and other angles are being investigated. The survey is still in progress and will likely be continued for some time.

The author acknowledges his indebtedness to Mrs. H. O. Fullerton, Mr. H. H. Kirby, and Mr. H. A. Fellows for analyzing the survey-forms and to many who kindly assisted in distributing and in collecting the forms. Among the latter he wishes particularly to thank the departments at Nela Park, various factory-managers of the National Lamp Works, Mr. G. B. Regar, Mr. C. M. Masson, Mr. C. H. Ferris of the Illuminating Glassware Guild, and Mr. J. E. North of the Cleveland Electrical League. Many others assisted in one way or another.

DISCUSSION

P. S. MILLAR: These two papers which are now before us for discussion are complementary in character. Mr. Macdonald's paper divides homes respectively into houses and apartments. The Committee which he represents on this occasion sent its own surveyors to these homes and got a good deal of detail, being interested and fairly well-instructed observors, and they are therefore able to make available such things as photographs of luminaires which were shown and foot-candle measurements.

Mr. Luckiesh divides homes into those which are owned and those which are rented. As I understand it, about half of the data which he has obtained was provided by the occupants of the homes.

The data for these two papers were gotten at in radically different ways and the two tend to substantiate each other. I think Mr. Luckiesh's average home is slightly larger and perhaps represents a little more money than the home that Mr. Macdonald has reported on, which is only a natural difference between the class of homes to which a lamp man has access and that to which a testing man has access. (Laughter).

These two reports give us, I think, an excellent picture of residence lighting as it is to-day and furnish a benchmark from which we can measure improvements as the years go by. We are very much indebted to the Association of Edison Illuminating Companies' Committee and Mr. Macdonald and to Mr. Luckiesh for making all this information available. It lies with us whether we will apply it constructively or not.

GEORGE AINSWORTH: Has Mr. Luckiesh, in obtaining the figure 2.5 convenience outlets per residence, considered emergency sockets attached to fixtures as falling within the class of convenience outlets surveyed?

G. H. STICKNEY: We owe a very deep debt of gratitude to the people who have made all this data available for us. We are undoubtedly all facing the same problem in trying to discuss these papers, in that there is such a mass of data, that we have not had time to really analyze or study them. But they give us something we can work with right along, and that we can use in finding out where we stand and how we are going to go ahead toward better lighting.

Another thing that struck me was the bogey, if you may call it that, that Mr. Luckiesh established. We are a selected group here, people who ought to have pretty well lighted homes, but I wonder how many of us would qualify under his prescription for a purely utilitarian home. For example, he recommended portables. I just counted up in my mind how many I have in my house, and I have seven. I would not be very much surprised if that were a little above the average of most of us, although we ought to be able to use that many to good advantage.

Perhaps one of the reasons why the country has so poor lighting is that many of those who are active in the lighting industry are not themselves entirely living up to the standards that we would like to preach to others. I would like to suggest, therefore, that each one of us when we go home, take this bogey of Mr. Luckiesh and see how well we qualify under it. Then perhaps we can do something to improve our own lighting and get an appreciation of what it means to us. Each time I have improved my own lighting, it sold the subject a good deal stronger to me. By convincing ourselves more thoroughly, we can teach the other people more effectively and become better leaders in the procession toward better lighting.

F. C. CALDWELL: I do not know where you could get better evidence for the arguments I made yesterday with regard to the need of more educational work, than appears in these two papers; more educational work among the people generally. I would like to emphasize this fact: this situation will have to be reached largely,

if it is reached at all, through general educational work; these prospects are not big enough to justify very much expenditure of time and money in trying to sell to them. These prospects will not be reached to any great extent through ordinary commercial methods. They can only be reached through educating the people generally to an appreciation of better lighting.

E. D. TILLSON: I would like to echo what Professor Caldwell has just said. I think that we have reached the saturation point by direct sales methods, to a large extent, in lighting, and that if we are to go onward, it will have to be by more indirect methods, and by education.

Mr. Hogue has been conducting an educational campaign in Chicago on residence lighting. I would like him to tell you about it.

I think the moral of Mr. Macdonald's figures is terribly obvious to the central station at least. It is evident that there are too many fixtures with a multiplicity of sockets. He says that in a later survey now in progress, about 33 per cent of the sockets are not normally used, and I think—

N. D. MACDONALD: Eleven per cent.

E. D. TILLSON: What was that figure of 66 per cent, Mr. Macdonald?

N. D. MACDONALD: Sixty-six per cent was the usual use of sockets.

E. D. TILLSON: That is what I meant to say; that 11 per cent of sockets are unused, but that does not take into account a great number of sockets that are practically out of use a good part of the time, namely about 33 per cent. We find that borne out all over in the city of Chicago; that a room will have four sockets and a ceiling fixture, and only one of those sockets will have a lamp in active use. We have plenty of wattage in that room, theoretically, but actually we have not; and there is a great exchange or transfer of lamps from one room to another. If there is a 4-socket fixture and one of the lamps burns out, no attention is paid to it; another lamp burns out and a little concern is felt. When they get down to the last lamp, there may be something done. Then if a lamp fails in the kitchen, the housewife takes one of the four lamps out of the living room and puts it in the kitchen; and if one burns out in the bedroom, another is removed from the living room and put in the bedroom. That of

course does not apply to the high class homes, but to the average and lower class residences which represent the bulk of our business.

I think that we should uphold the hands of those who are promoting portables and lighting fixtures, one relatively large wattage lamp per fixture, largely concealed, with low luminosity, or at least with no glare. It will get away from these objections I have been speaking of, and it will make for much better lighting.

I was much pleased to see a short while ago that another important manufacturing company of Chicago,—they are distributors of high class portables all over the country—have come to that view and are getting out now a line of semi-indirect portables with a single lamp to be used with a Type C bulb. The idea is spreading gradually.

R. S. HALE: There is one thing I would like to speak of: the reason why there are so few convenience outlets is a thing on which we can direct education to where it will do good.

The reason there are so few convenience outlets is because of the so-called 660-watt rule of the National Code, which itself does not prohibit convenience outlets, but is interpreted by a very large number of municipal and underwriters' inspectors so as to require a convenience outlet to be on a separate circuit, adding thus very much to the cost. I can not speak from personal experience outside of the Boston District, but all through the Boston District, if you start to add a convenience outlet, the wiring contractor will say, "Well, I will have to run that back on a separate circuit to the meter," and that adds so much to the cost that people do not put them in.

We can do some educational work on that by directing it partly to the local inspectors, persuading them to the idea that it is very much better to have convenience outlets put in where the flat irons, toasters and percolators can be used off the convenience outlet rather than off the socket; and also if you will direct your educational work to the Committee that makes up the National Code, which is now at work on this subject—and I have great hopes that they are going to change the Code so as to make it clear that a convenience outlet may be put in on the same circuit with lamps, without any penalty.

You can do real educational work in two ways: One, by directing it at the committee of the National Fire Protection Association, which is working on it; and two, by directing it at the inspectors and persuading them to let us put in more convenience outlets.

J. C. Norcross: Referring to the remarks of Mr. Hale, I think that education of the customers might help in the problem of empty sockets and removal of lamps from one room to another. The matter can be handled by the central stations in their method of getting lamps into the customer's hands. I feel that where a company has a renewal system which makes it convenient and easy for a customer to obtain lamps, you will find the sockets are kept filled much better than in those cases where customers have to actually buy their lamps. In the latter case, customers will put off buying as long as they can; as long as they have lamps in fair condition; while if a company furnishes the renewals and makes is convenient for the customers to obtain their lamps, they will keep their sockets better filled.

Ward Harrison: As Mr. Millar has said, these papers contain so much information on home lighting that it might seem as if together they entirely cover the subject. There is a question, however, in my mind as to the meaning of the word "shade" in speaking of home lighting, for which I have tried to find an answer in Mr. Macdonald's paper. I am not sure whether I have interpreted it correctly or not. Figure 11 seems to indicate that the lamps in living rooms in the home are pretty well shaded. In apartments 76 per cent of the chandeliers and 68 per cent of the showers or pendent fixtures are equipped with shades or reflectors. For houses the corresponding figures are 64 per cent and 75 per cent. In other words, about three-quarters of the lamps are apparently shaded. On turning to the next page, however, we find that in apartments 58 per cent of the bare lamps are visible and 39 per cent in the houses. I wonder if in the case of the apartments, it would be correct to state that 58 per cent of the bare lamps are visible, while only 25 per cent are without shades, meaning that more than one-half of the shades are either of clear glass through which the lamp can be seen quite as well as though the shade was not there, or are equipped with shades decidedly

too shallow. If this is the case it seems as though it should be emphaszied, for otherwise the casual reader will assume that lamps in the home are pretty well shaded.

One other point which might perhaps be misinterpreted, is the statement in the conclusion, that, owing to height or inconvenience, there is trouble in replacing 25 per cent of the bulbs. Unfortunately, the surveys seem to indicate that the lamps which are most accessible are those on low chandeliers, probably without any shades over them. I am interested in knowing whether the conclusion should be drawn that in specifying fixtures and in influencing practice we should try to make the lamps more accessible or less accessible.

LOUIS BELL: Mr. Chairman, there is one point in the matter of residence lighting which has not come up, to which I think attention should be directed to very sharply, and that is the effect of the coming of the gas-filled lamp in small sizes on the whole question. It is very clear that we are in serious trouble now from bare lamps, lamps improperly shaded, or not shaded at all. The handwriting is plainly on the wall as regards the change from the vacuum lamp to the gas-filled. We are now down comfortably to 75 watts. A good many 50-watt gas-filled lamps are in existence and in use, and unquestionably some of the yet smaller sizes will come, so that within a very short time the gas-filled lamps in domestic sizes are going to be fairly common.

That will mean a period of the worst lighting that the art has ever seen, unless we get busy and educate the householder to the difference. Imagine, for example, the effect of putting a 50-watt gas-filled lamp in the average abomination of a Colonial wall bracket with a bogus candle! It is bad enough now with a bare 25-watt lamp. What will it be with a 50-watt gas-filled?

The same difficulty is going to affect very seriously all of our present fixtures, except the portables. The portables are usually well shaded enough to stand it and give good results, perhaps improved results, so I am very much inclined to think that the portable will have to be pushed in an educational way as against the other forms of lighting fixtures, into which these very high intensity lamps can be put with most unpleasant effect. I think the change in the art in that respect is something our educational powers should take up very actively.

NORMAN MACBETH: These surveys and reports showing conditions that can hardly be endorsed by the Society are, if we consider the fixture sales campaigns and a large proportion of the advertising of the fixture and lamp manufacturers and the central stations, with of course commendable exceptions, remarkably up-to-date.

Many of Mr. Macdonald's horrible examples were but recently campaigned by central stations, one of which I believe is a sustaining member of the Society. It is my impression that a casual inspection of our daily newspaper advertising will show more of this kind of equipment offered to the householder than of the kind that would meet the approval of the writers of these reports.

For many years the bulk of the advertising of the lamp manufacturers has been to fill existing sockets—"When you buy a lamp get an XYZ"—"Fill the empty sockets with XYZ lamps"—"Buy a carton of six and have them handy"—"Buy a lamp backed by a laboratory," etc.

"Save two-thirds the cost and get the same light" has run so many years that to-day we find the uppermost question in the mind of the prospective purchaser is "What will it cost?" Lighting dollars bulk up larger than any other kind of dollars to the extent that you could well believe that where the average dollar was 100 cents a lighting dollar could not be less than 300 cents. The lighting dollars saved, however, will not buy any more gallons of gas than each 100 cents saved from some other source.

I have no intention of criticizing this kind of advertising. The advertising manager of lighting accessories knows his business and must produce for his client. XYZ as a manufacturer is satisfied to fill all the existing sockets—let the Society or someone else in a position to build for the future create the extra ones.

However, it just shows what our lighting advertisers have proven to their own satisfaction—that the lighting field is different—Kodaks are advertised around the results—snapshots of individual interest—not cameras, how they are made nor particularly who makes them. The linoleum, oilcloth and manufacturers of painted roofing materials are pushing the use of their products into other rooms in the house than the kitchen. Their advertising is concentrated on the pleasure afforded and the utility advantages

of these floor coverings rather than to relative costs of bare or carpeted floors vs. linoleum and there is little that is dominant in the copy as to what these materials are or how they are made, and they show a total absence of our advertising fixture manufacturers' point of view, "all for $19.98."

Take any typical lighting fixture or lamp advertising to the householder and substitute for fixtures or lamps, linoleum, rugs, hot water heaters, automobiles or what not, and compare this rebuilt copy with that appearing to-day for the manufacturers or distributors of these other home furnishings. Take the advertising pages such as they are in our magazines and columns of our newspapers devoted to the home or home furnishing—match this space up with the lighting advertising in the same publications and I believe we will have the answer to the recommendations in these papers.

The Society membership is composed of individuals interested in the advancement of the science and art of illumination. The present state of the art as exposed in these surveys is in my opinion right up-to-date if we consider that big bodies move slowly and that all the educational effort of the past ten years by the men who make a business of lighting has lead right up to this result.

If we of the Society desire to run counter to the commercial trend and raise the standard of equipment and illumination I believe we should seek out those now responsible for the present actual standards and educate them up to our standard or seek out the concerns who would profit by a change for the better and persuade them to offset the advertising of poorly designed equipment through educational advertising and text articles to raise the level of discrimination of the owners and users of houses on lighting matters.

I recall an experience of several years ago with a speculative builder. We sold him the idea of better lighting, and of course it cost more than his usual kind. After this one set of houses had been disposed of, he said "Never again." The purchasers of his houses had shown no appreciation for his increased expense for good lighting equipment. He could just as easily have sold his houses, and has done so since, with these $19.98 sets which better match up with the householders' idea of modern lighting.

J. B. Taylor: These two papers cover similar work but differ in one respect. One has the word "homes" in the title but throughout the text speaks of "residences," the other paper has the word "residences" in the title, but in the following text almost invariably uses the word "home."

This might indicate that there is no distinction in meaning between such words as "house," "home" and "residence." Now, in spite of the fact that there is a deal of bad precedent for calling any house, whether occupied or not, a home, this Society should not aid and abet the breaking down of a distinction in terms which have long been recognized and eulogized in poetry and song. A house or residence can be designed, build and sold by architect, contractor or agent, but it can be made a home only by the occupants.

Design, construction and fittings, including lights and fixtures, can do much to improve the value of a house, and also much to make or mar its attractiveness as a home. The engineer will succeed better in the work of demonstrating and introducing improved residence lighting features if he recognizes the differences between the physical and the psychological things in lighting at the same time that he bears in mind the difference between the tangible "house" and the intangible "home."

Walton Forstall: I would like to ask Mr. Luckiesh why he used the term "fixture" in view of the recent adoption of the word "luminaire"?

G. B. Regar: Referring to Figure 11 in Mr. Macdonald's paper, I notice that there is a higher percentage of shades used in houses than there is in apartments. This might signify that the apartment resident is more transient or perhaps not as interested in fixing up his living quarters as the man who lives in a residence.

The percentage of both frosted or bare lamps in both apartments and houses might be misleading for the reason that the tendency during the last few years on the part of the fixture manufacturers has been to favor colonial candle effect fixtures with frosted lamps especially in the dining room and living room, and they cannot be considered as poor lighting, especially if they are low wattage lamps in light colored decorated rooms.

O. R. HOGUE: Mr. Ward Harrison has asked me to say a word about our Home Lecture Course.

During the month of June of this year, we presented a lecture on home lighting before twenty-six organizations, with an aggregate attendance of 4,821. In order to promote this lecture, the following advertising material was used: Nine hundred and eighty-seven posters, 17,900 flyers, 9,475 announcements, 4,343 envelopes of literature distributed to audiences.

As a further inducement to attend these lectures, a radio concert was given each evening, both before and after the lecture. Posters were distributed to store owners in the neighborhood where the lecture was to be given, which posters were displayed in the store windows. The flyers were distributed by boys on the evening of the lecture.

Suggestions for home lighting fixtures were displayed on racks and also in a booth designed for the purpose. We also showed a large assortment of colored lamps, which were colored by a process known as the "Spramel Finish."

In addition to this, we prepared and distributed a new booklet on home lighting; we also used other booklets, published by the N. E. L. A. and the Society for Electrical Development. We had on exhibition two miniature apartments, one showing good and the other poor residence lighting. This exhibit alone created considerable interest, and I would advise that they, or something similar, be presented in conjunction with a lecture series on the subject.

This entire equipment, including the radio outfit and antenna, can be loaded on one truck. This truck usually reached a location about four o'clock in the afternoon, and was ready to leave about eleven o'clock in the evening.

Our program for an evening's entertainment was as follows: The doors were opened at about six o'clock in the evening, so that people could visit the exhibits. Demonstrators were on the job to instruct visitors on good and bad lighting. The radio concert started at half past seven o'clock and lasted approximately one hour, at eight-thirty a twenty-minute illustrated lecture was given. The lecture was purposely made short and snappy, so that it would not tire the audience. After the lecture the radio

outfit was again put into operation, and this program would continue as long as we could pick up the broadcasting stations.

In most cases, the organization under whose auspices the lecture was given served ice cream and cake, for which they made a charge, but there was no charge made for the lecture and radio concert.

From this experiment, we found that this sort of exhibition and lecture attracted the home-loving class of people; they all seemed very much interested in good lighting, and in many cases we received orders for tinted lamps.

The expense of this month's lecture series was very nominal.

I believe that central stations as a rule have been very lax in promoting home lighting, and that this is the opportune time to sell the residence customers better lighting. It is being done very successfully by several central stations, who have equipped electric homes for exhibition purposes.

This matter was brought up very forcefully at the Edison Convention in 1921, and I appreciated very much its being taken up seriously at this convention.

As Chairman of the Commercial Section of the N. E. L. A., I have recommended that we feature this subject at our next convention, to be held in New York City on June 4-8, 1923, inclusive. We are very fortunate in having Mr. Luckiesh to handle this subject. He will be given ample time to present it on the floor of the convention, and there will be organized discussion. By this means, we hope to standardize home lighting equipment, and to introduce into the home the tinted lamps.

M. Tillson brought up the subject of empty sockets in the city of Chicago. During the war period we discontinued our free delivery of lamp renewals, and established lamp stations. Our customers were used to having us bring lamps to their doors. No doubt the discontinuance of this service had a great deal to do with empty sockets in our City. We have, however, resumed this lamp renewal delivery service, and I believe the condition mentioned by Mr. Tillson has been eliminated. We deliver free of charge 60-watt lamps, and ask a small additional charge for lamps of other sizes, and for tinted lamps.

N. D. Macdonald: There have been a good many questions asked and I will try to answer them as briefly as I can. First,

taking the results of the Edison Association Survey of 1921 of 1,500 houses, some data which is just becoming available at the present time from a survey of 5,000 residences by the Edison Association, and Mr. Luckiesh's data, and comparing the three, weighting the results by the different methods under which these data were collected—it is surprising how closely the figures check.

Mr. Luckiesh spoke of the difference in classification of luminaires. I think that the difference may be explained by the fact that in Mr. Luckiesh's survey, a list was made of the luminaires in the different rooms. In the Edison Association Survey a list was made of the most used lighting appliance. He finds that in living rooms there are 58 per cent showers. We found 29 per cent in apartments and 16 per cent in houses, but there is no doubt but that if we had listed all the showers found, we would have found as many as Mr. Luckiesh did. In a great many cases table portables were listed where there was a shower installed which was not used.

Replying to Mr. Tillson's point, our survey disclosed the fact that 11 per cent of the sockets were not used because they were abandoned. The question of 66 to 75 per cent lamps being used in living rooms and dining rooms, is a little different one. Living rooms and dining rooms are somewhat over-equipped from the householder's point of view in order to take care of overloads whenever they occur. If the householder has a reception or a party the full equipment is used, but normally only about three-quarters of the equipment is used.

Mr. Norcross' point is a very good one. I remember about a year ago I had occasion to put through a rush printing job in a small print shop in the city of New York. During the night we found in the print shop that there were fourteen sockets, but only three 100-watt lamps for the fourteen sockets. The men carried the lamps from the composing-stone to the press and from the press to the make-ready table, as they were needed. On account of this lack of supply of lamps, two operations could not be carried on simultaneously.

The answer to Mr. Harrison's question is that in a good many cases the shade does not shade. We found a great many re-

flectors where one sitting got a view of a bare lamp underneath the shade. In a good many cases also the shades were of almost clear glass.

Replying to Mr. Harrison's question about the height and inconvenience of reaching lamps. There was no attempt on my part to make any recommendation from the illuminating engineering point of view. I am simply recording the fact that in 25 per cent of the cases, it is somewhat inconvenient for the householder to reach his lamps. This, I think, is a question for the fixture designer.

There is just one more point. There has been a good deal of discussion of this question of wall or baseboard receptacles. One very interesting point which was brought out in our survey of last year was that in one city, the city of Rochester, there was found to be about twice as many baseboard and wall sockets as in any other city. The reason for this is not apparent to me, but there is certainly one moral to be drawn from this fact and that is, that if the city of Rochester can raise the number of baseboard receptacles to twice the number of any of the other cities, the city of Rochester ought to be studied by some of the other cities.

M. LUCKIESH: I am very much pleased with this paper by Mr. Macdonald which attacks the matter from a different angle. Doubtless Mr. Macdonald had the same difficulty that I did in presenting his paper; it was very difficult for me to determine what to present and how to present it out of the tremendous mass of information. In order to make some of the commercial phases of it available as soon as possible, we have written up some of the commercial side of it in a series of articles which is appearing now in *Electrical Merchandising*. After all, progress in lighting in residences and elsewhere must proceed through commercial channels.

A great deal is said about educational work. This Society is a committee on education itself, and I am going to say that I think this Society is doing about all it can in the way of educational work, and so are its members. We do not want to think that we are the ones that are slow about the educational work; the people that are slow about it are those that we are trying to appeal to now, and at all times. I think we can say that the central station, and the fixture dealer, etc., are the people who

must spur up a little bit on educational work. We are a limited body; we have limited means, but I think we are doing a lot of work notwithstanding these limitations.

Mr. Macbeth asked who profits by it. Of course he knows the answer. Well, my answer is that everybody does. We cannot expect lighting to progress in any field as long as it is uncomfortable and inadequate; and I think any broad-minded individual will realize—whether he sells lamps, or electricity, or shades, or fixtures, or anything else—that if we make lighting comfortable and desirable, everybody will profit, even the individual using the lighting.

Mr. Ainsworth asked what we mean by convenience outlet. We have standardized that term for any outlet in a baseboard, wall or piece of furniture to which an appliance, including a lighting appliance, can be attached. We did not include convenience outlets on fixtures. I think there ought to be in many fixtures such a thing provided, but we did not include as a convenience outlet a plug in a socket on a fixture.

Incidentally, in that connection I would like to mention that the duplex convenience outlet is very useful and we are installing a great many in the modern electrical homes.

In looking at surveys like these, we are inclined to get the idea that there is not much progress being made, but one who is following this field is now experiencing considerable gratification in the progress that is being made. There are homes to-day that are being wired with twenty-five, thirty, and forty convenience outlets, belonging to people who are not interested particularly in any electric or lighting propaganda, and I think the "modern electrical home," from the standpoint of electric lighting, is one of the finest means of educating the public.

For example, the first three modern electrical homes in Cleveland had eighty-three thousand visitors, fully exposed to the possibilities of lighting and electrical convenience in general. I believe this "demonstration method" is much more effective than magazine advertising.

This may not be the place to mention the Committee on Education, but I think the Committee on Education, if it assumes that its field is as broad as the Illuminating Engineering Society, is taking a tremendous job on its shoulders. If we have a com-

mittee on education again, we ought to have a dozen sub-committees, each one of which should take a specific field.

Incidentally, the Fixture Dealers Association of Cleveland is entirely with us on shading lamps, notwithstanding the great popularity of the candelabra lamp to-day. Yet on the other hand, we go to the fixture market and talk to them about what good lighting should be, and we state that no lamp should be unshaded. But when we get through talking four of five of them get hold of us and take us down to show us proudly their fixture displays—and we find the unshaded candelabra predominant.

I consider portable lamps have a great field in residence lighting, for a good many reasons, and it is rather gratifying to know that that is one kind of lighting the public has sold to itself pretty well. The portable lamp is growing in use right along.

Speaking of shades, there is no difficulty in my mind about what a shade is, and I will not go into that. So many of the fixtures of the past few years have been installed without any shade holders. The lighting in this room is an example. Yet to-day we have shades that are supported by the lamp. To-day there is no reason for any lamp being unshaded. There are shades available that do not need holders, so that there is no excuse when it comes to the type of shade.

I divided my survey into rented and owned homes. Mr. Macdonald did the same thing practically when he divided his into apartments and houses. I think the rented and owned homes represent two entirely different commercial problems. Good lighting must proceed through commercial channels and therefore we should separate the data in this manner.

Dr. Bell spoke of the gas-filled lamps in the small sizes as something that is going to give us abominable lighting. When the smaller sizes arrived we got out the so-called White Mazda for just that reason. One of the hopes we have is that a survey of this sort will tell us how many showers, for example, we have in the homes; and with the gas-filled lamps coming out it simply means that we will have to equip those showers with very dense, deep glass shades or as Dr. Bell has said, we are going to have abominable lighting.

Mr. Macbeth mentioned the matter of advertising. I think very fine progress has been made in the last two or three years

in the advertising of some companies. They are beginning to introduce lighting pictorially and I think that should have considerable influence in the right direction.

Mr. J. B. Taylor distinguished the difference between residences and homes. When we are dealing with the esthetic side, and all the things that go to make a house a home, we often use such a phrase as, "artificial lighting goes far to make a house a home." I think that is a good distinction. I used the word "home" in this paper because it is shorter than "residence" and I do not believe my use of the word in this paper is misunderstood. Furthermore when it comes to a survey of this sort, we must confine our data to wiring, sockets, fixtures,and so forth, because we can not take the responsibility to distinguish whether we are surveying a house or a home.

Mr. Forstall mentions my use of the word "fixture" which I used very deliberately in this paper. I will mention that in a few minutes in connection with the Code of Luminaire Design, and justify my use of it, from my standpoint at least.

W. E. Clark: May I ask just one short question? Is there available a drawing or an electrotype of the ideal home with all these convenience outlets, so that electrical contractors who might like to have them printed and circulated, could do so conveniently?

M. Luckiesh: There are a great many of them now. If you want the modern electrical home idea, I can send you a number of them, but this "conservative ideal," which is probably a third as well wired is described in words here so that it can be transcribed to a drawing.

Incidentally, there is one other point. Mr. Stickney mentioned the matter of portables. He says he has seven in his home; we specify eight. There are many ways in which we could have arranged fixtures to satisfy the utilitarian requirements of what we call this conservative ideal. We might use less portables and more brackets, or more fixtures of some kind. So if you do not have eight portables you do not need to assume that you are not up to this conservative ideal, because for example you might have a bracket attached over the bed or something, which would simply add one more bracket and one less portable.

E. D. TILLSON (Communicated): I do not quite agree with Mr. Hogue as to the effect of free lamp renewals. It is true that such a policy reacts in part against empty sockets. But from actual observation I know that even where lamps may be had for the asking, and are delivered right to the door, yet there are many people who will go without lamps, and transfer them from one room to another rather than go to the slight trouble of merely calling up the Central Station.

LIGHTING OF THE FOOD INDUSTRIES*

BY W. H. RADEMACHER**

SYNOPSIS. The investigation reported in this paper indicates that one element of plant management has been somewhat overlooked. Lighting men have known for a long while that proper illumination is a very important factor of sanitation. A well lighted shop is perforce clean, for there are no dark corners or shadows in which refuse is allowed to accumulate. Proper lighting also assists in increasing production, maintaining a high morale among the employees and promoting safety.

The author presents data on lighting conditions in a considerable number of factories allied to the food industry. It may, in general, be said that the standards are far too low. Inadequate lighting exists in a high percentage of the plants. A few notable exceptions where the benefits of proper lighting have been appreciated are illustrated and discussed.

The following scheme of treatment is used in discussing the lighting requirements of the various industries: general character of building, analysis of the processes of manufacture, present lighting practice, recommended practice as to intensity, type of equipment, and method of lighting, and special or peculiar lighting requirements.

The industry is divided into the following headings, each of which is discussed individually: grain elevators, flour mills, bakeries, breakfast foods, canning, meat packing, ice cream manufacturing, chocolate and candy manufacture, fruit packing and milk testing.

As practically every community has some establishment devoted to the handling or preparation of food products, the data contained in this contribution should be of universal application and value.

The subject of food production, conversion and manufacture is one of ever timely and important interest, for food has ever been and always will be the most important factor in the health, welfare and general activity of the human race. Without its production and manufacture on the enormous scale which exists to-day, life in its present forms would be impossible, and our leadership as a nation would cease.

It is rather interesting to look back a few generations and observe the radical changes which have occurred in methods of food conversion. One of the many duties then preformed by the sturdy housewife was the preparation of flour and the baking of bread. She would grind by hand the required amount of grain,

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** Lighting Service Department, Edison Lamp Works, Harrison, N. J.

mix it with the proper ingredients and bake it in her homely oven. Later the duties of grain preparation passed into the hands of the village miller, the producers of his neighborhood bringing to him their sacks of grain for conversion into flour, but still the preparation of dough and the actual baking remained within the confines of the home. Tracing this activity still further, we find that bakeries, to which the formed loaves would be brought for baking, sprung up in villages. As the population increased the business of grain preparation and bread baking likewise expanded, and gradually moved further and further from the home until to-day we have a huge industry bending its entire energies to the efficient handling and production of grain and cereal food and the baking of bread and allied products.

Similarly in the preparation of meats, there was a time when every man was his own butcher, doing his own killing, cutting, smoking, salting, etc., but this work gradually passed into the hands of the village butcher, then through necessity there came local abattoirs and eventually the enormous stockyards, slaughter houses and packing plants of to-day. The evolution of our modern canneries, milk condensing plants, fisheries, etc., has been very much the same. It is with the application of artificial light in these modern industries that this paper intends to deal.

When considering the wonderful progress made in a branch of industry, such as this one, one is naturally prompted to inquire what manufacturing methods are employed and what changes, if any, have been made in plant operating practice since their inception. Do they compare favorably with the practice in other industries, and are they consistent with the character of products which are offered us?

Generally speaking, the methods to-day employed are seemingly the acme of perfection and efficiency. Modern minds have evolved machinery and methods of handling and utilizing food stuffs in ways which were never dreamt of in the days of our forefathers. Sanitary conditions have been much improved and most of our plants are to-day as clean as the proverbial whistle. Progressive manufacturers are to-day utilizing every available agency for promoting efficient plant operation, complying with the stringently enforced pure food laws and acquiring the good will of the public.

Artificial illumination, however, seems to be one factor which has suffered serious neglect in many plants.

Light in some form is a vital element entering into the operating efficiency of every industry. We find that manufacturing buildings are invariably constructed so that the maximum amount of daylight illumination is insured, it apparently being realized that daylight illumination of a high order is well worth having. It seems almost paradoxical then that a good many of these plants which are so well fortified from the daytime manufacturing standpoint have artificial lighting systems which may be considered far from adequate. Artificial light, by many, still seems to be considered a necessary evil and lighting systems under these conditions are merely the application of a lamp bulb, as such, rather than the procurement of real illumination.

In considering the problem of illumination of any industry the first query which confronts us is, "what are the benefits of *good* illumination to this industry?"

The writer in compiling data for this paper interviewed many superintendents and operating men responsible for the efficiency and output of typical food manufacturing plants. One of the questions which was usually placed before these men, was "do you consider good artificial light necessary and desirable in your establishment." In summarizing the replies made to this question, it was found that the management of those plants with poor lighting invariably contended that their particular industry might be classed as a daylight industry and that in general very little work was carried on during the hours of darkness or under conditions necessitating artificial illumination. On the other hand, it is rather interesting to note that in other plants, almost exact duplicates, as far as products and working hours are concerned. the operating men said that they considered artificial light as being extremely essential and in general these were the plants which had adopted a high intensity of properly applied light to their requirements. When we remember that in the so-called daylight industries there are approximately 300 working days per year in which there is an average of 2 hours per day during which artificial light is required, we can quite fully appreciate that really good artificial light is essential and has a distinct bearing on the plant's successful operation. (It remains for us in the lighting business to sell the idea to the industry as a whole).

This is especially true since the period calling for artificial light occurs at the end of the working day when the vitality and morale of the workers is at low ebb, when they are under the influence of bodily, mental and ocular fatigue. It is at such a period as this that stimulating and elevating influences are required more than at any other time. Inadequate light at such a time is but another millstone added to the already weighty burden of depression upon the worker. Good illumination will tend to keep the curve of production level and that of casualities from rising.

There are certain derivatives of good lighting and their relative importance in the food industry seems to be as indicated by the following order or treatment.

A. Sanitation.

To-day the operation of practically all food preparation plants is under the eye of Federal authority. Cleanliness is imperative, for the foods produced are distributed widely and if contaminated in any way whatsoever are liable to carry disease to all parts of the world. Periodical inspections by government authorities are made, not only of the food-stuffs themselves, but of the conditions under which they are manufactured. Cleanliness of a plant as a whole is something which must undergo the most rigid surveys. That good lighting means cleanliness can be readily appreciated, for with a high intensity of well-diffused light refuse and foreign matter is not likely to be allowed to accumulate, for where the chances of detection are high and where untidiness is easily visible greater care is always taken by those responsible for the possible existence of such conditions. Furthermore, the workers themselves are likely to be more particular in their personal cleanliness. The general aspect of an interior under good lighting in itself conveys the idea of cleanliness and this reacts eventually upon those working beneath the lighting, making them more careful and more particular of their surroundings and themselves.

B. Safety.

Proper intensities of well-distributed light make it unnecessary for the eye to continually readjust itself in moving about from place to place, enable one to perceive clearly at all times, and eliminate the possibility of misjudging the placement of objects, etc. In the food industries much intricate automatic

machinery is used, with many moving parts and extremely sharp knives are employed for various cutting operations; accident hazards which can be greatly minimized by properly applied light.

C. Increased Production and reduced spoilage.

In every food industry we find that close visual application of some character is necessary. It is a known fact that good light quickens visual perception, and that further since the eye sees more readily other sub-conscious movements occur much more rapidly increasing output.

To illustrate this we might cite the case of a typical packing house. Here we find an area which is known as the killing floor, to which the cattle are driven, killed, stripped of their hides, and dissected. The actual work of killing requires only a medium intensity of illumination, but on the other hand the successful removing of the hides, which are eventually converted into leather, the cutting of the carcasses and removal of vital organs requires a high intensity of well diffused light. Keen edged knives are employed for this work and the workers must trust almost entirely to their keenness of sight in successfully separating the skin from the fleshy part of a cattle body and the severing of the various organs. Under a low intensity or poor distribution of illumination distinct visual perception is practically impossible. As a consequence miscutting is likely to occur which will result in the ruination of hides and spoilage of valuable cuts.

Observations on similar operations carried on under good and bad lighting demonstrate most emphatically that the time required to strip and dissect a carcass is very materially less under the well lighted conditions than under the poor. Not only is the man output greater but the quality of his work, the exactness of his cutting, etc., is of a much higher order. This is truly one of the many places where it might well be said that good lighting will make the difference between profit and loss.

A similar example is found in the fruit packing industries. Here operations of the sorting and inspection type are predominant and of greatest import. The fruit is selected not only for size, but also for color and ability to keep. Visual acuity is rendered more keen by the proper grade of light. Fruits of varying hues are more easily and rapidly separated and the possibility of passing low grade, unsalable and decayed fruit is minimized.

D. Indirect Effects.

The effect of good lighting on the morale of those working cannot be overestimated. The cheery atmosphere which results from good lighting, makes for a more alert, conscientious and enthusiastic attitude. Much of the work done in food manufacturing plants is of a routine nature, perhaps the most trying on the mental state of the individual. In a gloomy atmosphere grouchiness and despondency develop, followed by carelessness and general laxity.

Where a large number of workers are employed in areas filled with benches, machinery, trucks, etc., the problem of labor supervision becomes of considerable import. The average worker of to-day must be watched. He is inclined to loaf and lag if he thinks his superintendent or foreman will not see him. Good lighting because it enables quick or easy perception and eliminates shadows in which workers may lurk, facilitates the supervision of workers and greatly minimizes this problem.

Having briefly discussed the general relation of light to the industry let us next consider the processes as applied to particular products and the detailed methods of illumination which will produce results consistent with the above aims.

The following scheme of treatment will be adhered to as far as possible.

(a) General character of building.

(b) Analysis of the processes of manufacturing.

(c) Present lighting practice.

(d) Recommended practice as to intensity, type of equipment and method of lighting.

(e) Special or peculiar lighting requirements.

Grain Elevators.—Of our many food-stuffs those classed as grain and cereal foods are undoubtedly of the first order of importance. As far back as we can trace through history, we find facts relating to the growing and consumption of wheat and corn and to-day grain products still play an important part in our national commerce and our daily menus. The modern grain elevator is the keystone around which is built our enormous grain and cereal food trade.

The primary functions of the grain elevator are to receive via rail or boat bulk grain from the producers, commission agents,

etc., to clean, grade, weigh, store and mix these grains and redistribute them to carriers, either by rail or boat for further distribution and manufacture, or to mills for conversion into flour in the case of elevators which are operated in conjunction with such houses.

Grain elevators may be divided into two classes.

In the first, the elevators are what might be termed—self-contained, the storage bins and elevating machinery all being under the same roof. In the second, the elevating machinery is grouped in what is called the work house, while the storage is cared for in bins which are separated from the main house, but connected thereto through conveyors.

Elevator houses are huge rectangular structures the older group usually being of wood construction while the more modern houses are of brick or concrete. In the basement and connecting the work house with the bins, are found low ceilinged tunnels through which run belt conveyors. The upper floors usually extend unpartitioned throughout their entire length and breadth and are occupied by the driving machinery, belt conveyors, scales, elevator legs, and various bins. The ceilings are usually quite high and are broken up by projecting spouts, elevating legs, and overhead beaming and supporting members.

The operation of the typical elevator may be described as follows:

Wheat is brought into the car unloading platform, it is then pushed by means of automatic shovels out of the car down into the receiving hoppers. Endless belts carrying small buckets scoop up the grain and hoist it to the very top of the house where it is dumped from the belt, shot into spouts and directed across the top of the building to the garners from where it falls into the scales. From here through swinging turnheads, into spouts and longitudinal conveyors, it goes to certain bins to be held for cleaning or shipping.

These operations are for the most part automatic.

Grain elevator interiors are characterized by their exceptional dustiness and one of the biggest problems confronting the elevator operating men of to-day is that of dust prevention and removal. Much money and effort has been devoted to the elimination of this evil with varying degrees of success. Dust-collecting and

removing systems are in use in most modern houses, but even so, during the periods of grain movement, their interiors become practically enveloped in dust clouds. From the standpoint of artificial illumination this presents a serious problem.

The flying particles of dust naturally lodge on all surfaces presented to them. Lighting units are no exception, and they become rapidly coated with a dense layer of more or less inflammable and opaque dust. In going about a mill, it will usually be found that many of the lamps indicate their presence solely by a mere glow. Aside from the standpoint of light absorption, the prevalence of dust presents another serious problem, that is one of fire hazard. As a result of the many explosions which occurred in grain elevators during the period of the World War, the United States Grain Corporation, under whose supervision grain handling was then being carried on, in co-operation with the Bureau of Chemistry of the United States Department of Agriculture, conducted a dust explosion prevention campaign, and a survey of the causes of grain dust explosion.

One of the inferences drawn from this survey was that the incandescent lamp at times presented a fire hazard. The leading lamp manufacturers upon being acquainted of this fact inaugurated a survey of their own. with a view towards finding out if it really was dangerous to use the incandescent lamp in such interiors and how could best be applied with safety. A recapitulation of the results of this survey was present before the society during the Annual Convention September 26-29th, 1921, in a paper entitled "Incandescent Lamp Temperatures as Related to Modern Lighting Practice." As was pointed out at that time, it was found that fires or explosions which may be caused by incandescent lamps in dusty atmospheres are of two kinds.

First: In extreme cases, fires resulting directly from the ignition of dust accumulating on the lamp bulb.

Second: Explosions resulting from the accidental breakage of lamps in a dusty atmosphere containing the proper proportion of air and dust to form an explosive mixture.

By the proper application and protection of lamps, the possibility of trouble due to either of these causes may be eliminated.

The hazard attending the use of high wattage lamps in general overhead lighting systems is far less than that resulting from the careless use of small hanging lamps on drop cords.

Present day practice as indicated by Table I is in general unsatisfactory. The usual procedure is to apply bare incandescent lamps, usually Carbon or Mazda B in the 25, 40 or 60-watt sizes on drop cords at intervals of about 20 feet, and a hanging height of approximately 6 ft. above the floor as shown in Figure 2. The resultant distribution of illumination is very non-uniform; the intensity is low, the light sources which are in the range of vision are decidedly uncomfortable and the breakage risk and consequent fire hazard is very great. The claimed advantage of such practice is that the low hanging height makes it possible for the workers to readily clean lamps by wiping them with their hands as they pass along. Some of the more modern mills apply low wattage lamps in vapor proof globes at more frequent intervals, sometimes mounting them on the supporting columns, using a rigid mounting. This practice is substantially better and in mills of the more modern type with light surroundings, fairly good illumination is secured.

There is undoubtedly a large field in this industry for the use of higher wattage lamps in conjunction with vapor-proof globes equipped with reflectors and where necessary, guards affording protection from mechanical injury. (Fig. 1). The economy, minimization of fire hazard and improved lighting effect procurable should more than justify their installation. A well-designed unit is not unduly susceptible to the accumulation of dust and undoubtedly many of the fixtures now available on the market are quite satisfactory.

The demands for lighting in the grain elevator are, for safety, for the carrying on of rough operations such as the setting of belt trips, grain spouts, etc., and for some little closer visual work as the reading of scales. Intensities of from 0.25 to 1 foot-candle are to-day being almost universally employed for this work. These values of illumination are undoubtedly low and a substantial increase to intensities in the order of from 1 to 3 foot-candles should be adopted, for by so doing safety in working conditions would be materially bettered, in fact to such an extent that the increased wattage could be easily justified. Furthermore, the application of Mazda C lamps in suitable reflectors equipped with vapor-proof

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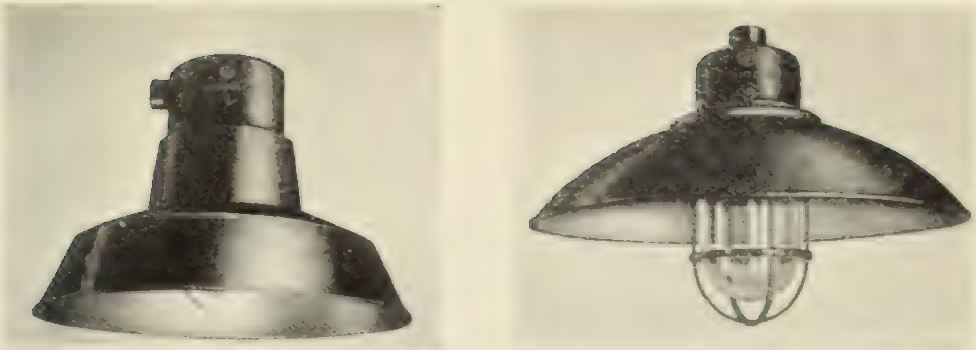

Fig. 1.—Typical vapor proof reflector of the type recommended for grain elevators and flour mill lighting.

Fig. 2.—Day view illustrating typical conditions encountered in a grain elevator. 25-watt Mazda B lamps in vapor proof globes on centers 12 x 14 feet. Absence of reflectors and dust accumulation results in decidedly low utilization of light, average intensity less than 0.5 ft.-c. Inadequate as it may seem it pictures one of the best installations inspected.

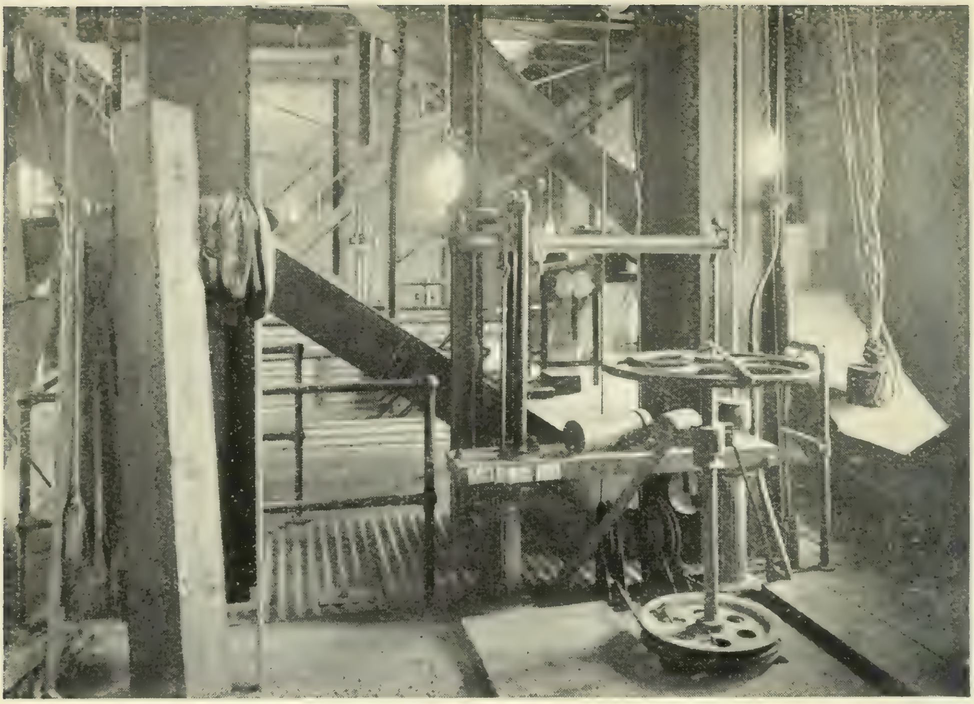

Fig. 3.—Day view of scale floor in grain elevator, unshielded lamps are almost directly in line with scale beam on which none too distinct figures must be read. Angle type or dome reflectors should be used here to provide "light on the object and not in the eye."

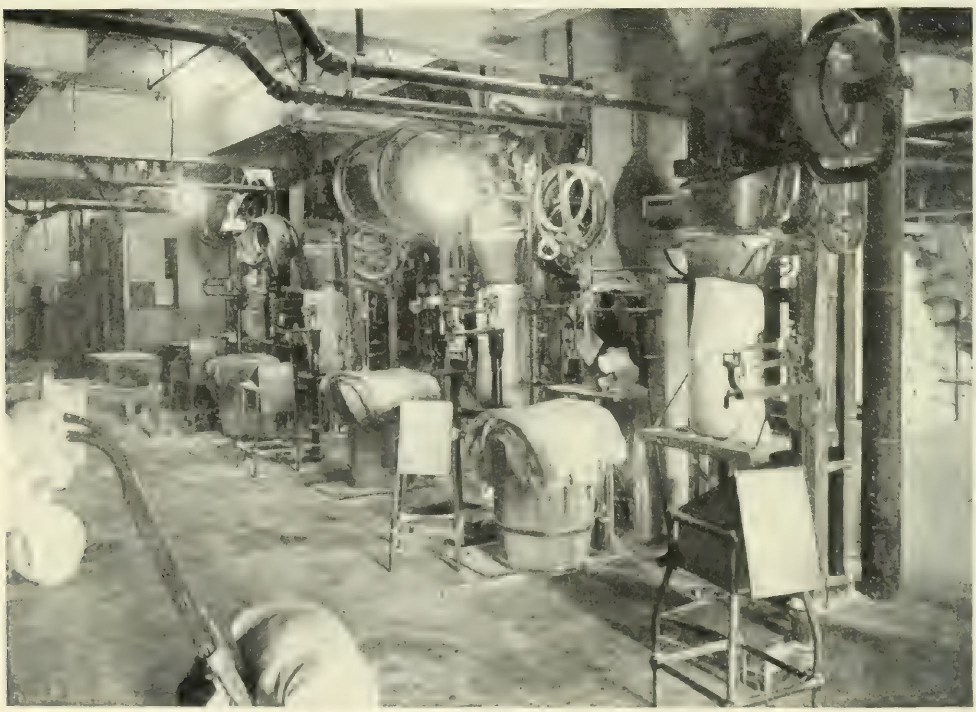

Fig. 4.—Day view indicating the character of lighting often employed at the bagging and weighing machines in the flour mill, a few 25-watt bare lamps are haphazardly placed and pulled over to some chosen position by a piece of string.

TABLE I.—LIGHTING STATISTICS COMPILED FROM INSPECTION OF 100 TYPICAL HOUSES RANGING FROM 60,000 TO 4,500,000 BUSHELS CAPACITY [1]

Kind of Lighting		
Plants using Oil Lanterns		1
Plant using Gas		0
Plants using Electricity		99
Types of Lamps		
Plants using all carbon lamps		21
Plants using all tungsten lamps (Vacuum)		42
Plants using all tungsten lamps (gas-filled)		1
Plants using carbon and tungsten Vacuum		26
Plants using carbon and tungsten gas-filled		5
Plants using carbon vacuum and gas-filled		4
Plants using oil lanterns		1
Use of Reflectors		
Plants using no reflectors		85
Plants using some reflectors		11
Plants entirely equipped with reflectors		4
Vapor Proof Globe Protection		
Plants using no V. P. globes		41
Plants partially equipped		46
Plants entirely equipped		13
Types of Reflectors		
Plants using all drop cords		53
Plants using all ceiling sockets		2
Plants using ceiling sockets and drop cords		9
Plants using ceiling sockets and wall brackets		5
Plants using drop cords and wall brackets		18
Plants using drop cords, ceiling sockets and wall brackets		13
Types of Wiring		
Plants using all conduit wiring		51
Plants using all open wiring		32
Plants using open and conduit		17
Lamps		
Average number of lamps per plant		230
Average size lamp used	(watt)	40-50

enclosing globes will make possible the procurement of a more uniform, efficient and comfortable distribution.

There are some areas in and about the average elevator which require other than general lighting, these being the scales, bins, freight cars, docks and ship holds.

In front of each hopper on the scale floor (the point where the incoming and outgoing grain is weighed), is a beam scale calibrated with figures varying in height from one-fourth to one-half inch It is essential that these scales be read accurately and rapidly.

[1] Since 100 is the basic figure the representative number are also equivalent percentages

The proper kind of illumination undoubtedly is an important adjunct to the attainment of these ends. The present practice consists for the most part of using one or more low-hanging bare lamps directly in front of the scales and usually on the normal line of vision, Fig. 3. This procedure is far from being good and a practicable solution of the lighting problem seems to be to mount one or preferably two dome shape reflectors, carrying 75-watt Mazda C lamps, about 3 feet above the level of the arm.

In the lighting of grain storage bins we have a rather interesting problem, and one whose satisfactory solution is an objective which has often been the hope of many operating men. Unfortunately, most operators have held hope but have taken no real steps towards investigating ways and means of attaining a satisfactory solution. Grain bins are in reality tanks ranging in depth from 60 to 90 feet in which grain is stored prior to shipment. It is frequently desired to look into these bins for the purpose of determining grain level. It also becomes necessary at times to enter the bins for the purpose of cleaning. The theoretical method of establishing the grain level is by means of a plumb line, while actual examination is made under the illumination furnished by a carbon or Mazda B lamp of low wattage mounted on a drop cord, in fact in 99 out of 100 plants inspected this practice is held. Unfortunately the common tendency of workers at these points is to use the lamp and cord as a plumb line. The lamp and cord are lowered into the bin and the cord is quite frequently chaffed or broken, causing short circuits and further are often left hanging in the bin only to be covered by grain at some later time. This is obviously an extremely dangerous practice and there are on record cases of fires and explosions which it is claimed can be directly traced to this cause. The ideal method of lighting these bins would be by means of a portable unit which could be mounted at the opening, projecting its rays into the bins and lighting the interior to an intensity of, in the order of one-half to one foot-candle. During the movement of grain, one of the most usual intervals of inspection, the interiors of these bins are enveloped in dust clouds. The lighting supplied at the opening must penetrate this cloud.

Apparently, the most practical unit for this service is a searchlight carrying a standard voltage lamp. One of the large railroad export elevators is now using such a scheme to its entire satisfac-

tion. Outlets are situated at convenient points over the bin floor, and units which are hung at readily accessible points may be taken when needed and located at whatever bin requires light, It becomes unnecessary for lamps or current carrying parts to be lowered into the bins themselves, and ample light is had throughout the interior even under the most adverse conditions.

It quite frequently happens that ships must be unloaded or loaded at night, in which event artificial illumination of some means must be had. For exterior illumination of this character it is the usual procedure to mount flood lights on convenient parts of the building training them on the areas where illumination is required. For lighting the ship holds, clusters of 60-watt lamps in a dome steel reflector fitted with a wire protecting guard and arranged for convenient plugging into receptables mounted along the deck side of the building are usually employed, while lighting the interior of cars is cared for in a somewhat similar manner. Undoubtedly a better effect and more efficient illumination could be secured at these points by the utilization of a dome-shaped vapor proof unit equipped with a guard and a Mazda C lamp, preferably bowl enameled, of a suitable wattage.

The following tabulation indicates the recommended lighting practice for grain elevators.

Section	Type of illumination	Intensity ft-c.
Machinery floor	General	3-4 ft.
Garner floor	General	1-3 ft.
Weighing floor	General and local	1-3, 8-10 ft.
Bin floor	General and local projectors	1-3, ½-1 ft.
Cleaning	General	1-3 ft.
Conveyor passageway	General	1-3 ft.
Deck and dock	General (Floodlighting)	1-3 ft.
Cars and ship holds	General	3-4 ft.

Flour Mills.—Closely allied to the grain elevator is the modern flour mill wherein grainstuffs are converted into flour. Present day mills range in size from those which convert but a few barrels a day to those having a daily output that ranges well into the thousands, but regardless of their capacity the operations performed and the lighting demands are much the same.

Flour mill construction is quite similar to that of grain elevators. Old construction is characterized by the multiplicity of cross-beams, struts, etc., necessitated by the type of architecture.

Modern practice, however, closely approaches standard factory construction. As in the case of elevators, the upper areas are broken up by conveyor tubes, spouting, etc. The machinery employed in various operations is usually arranged in rows with those parts demanding most light facing the windows.

The processes employed in flour milling involve a seeming multiplicity of treatments, but the main objectives may be classed as cleaning, tempering, separation of middlings and reduction to flour.[2] These operations are all of a semi-automatic nature, and the product is not touched by human hand from start to finish, being passed from operation to operation through spout conveyors.

Artificial light application in the majority of mills is very poor. The customary procedure is to place low wattage Mazda B lamps on drop cords at the place where light is desired (note Fig. 4) without regard to the procurement of efficent utilization, uniform distribution, or prevention of glare. As a consequence, interiors are usually gloomy, eye fatiguing, and even dangerous because of the prevalent shadows.

General lighting is most admirably adopted to the flour mill (see Figures 5 and 6), and can be best secured by the use of suitably spaced gas-filled lamps in steel dome reflectors, preferably equipped with vapor-proof globes. (See Fig. 1).

In modern flour mills laboratories are maintained for the inspection and testing of flour with regard to grade, bread-making qualities, etc. In addition to the general system of lighting of high intensity which should be provided in such an area, color-matching units are found to be highly valuable, inasmuch as they enable the accurate discrimination of slight variations in color regardless of natural light conditions. Such units are now being employed in some of the progressive mills.

The following intensities are recommended as a guide for good lighting practice.

Process or operation	Type of illumination	Intensity ft-c.
Cleaning, grinding, rolling, separating	General	3-6
Bagging and weighing	Localized general	6-8
Grading	Local	10-20

Breakfast Foods.—The breakfast foods produced under various trade names are far too numerous to discuss in so far as their

[2] For a detailed discussion of the process involved, see "Food Industries" by Vulté and Vanderbilt, pages 62-74. Publishers, Chemical Publishing Company, Easton. Pa,

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Fig. 5.—Night view of modern lighting applied to elevator heads and bolter distributors in a flour mill, 150-watt bowl enameled Mazda C lamps in RLM standard dome reflectors are used on 16-foot centers, 13 feet above the floor, they provide an intensity of 5 ft-c. The white surroundings aid the sanitary conditions and promote utilization of light.

Fig. 6.—High level lighting of the roller floor in a progressive flour mill, 150-watt bowl enameled Mazda C lamps in RLM standard dome reflectors are 10 feet above the floor on centers 8 x 16 ft, the intensity is over 12 ft-c.

Fig. 7.—A rare example of modern lighting applied to the mixing and bake room of a progressive medium sized bread bakery. The 18 x 18 feet bays in front of the ovens are illuminated by centrally located 200-watt clear Mazda C lamps in RLM standard dome reflectors producing a resultant intensity of approximately 3.5 ft.-c.

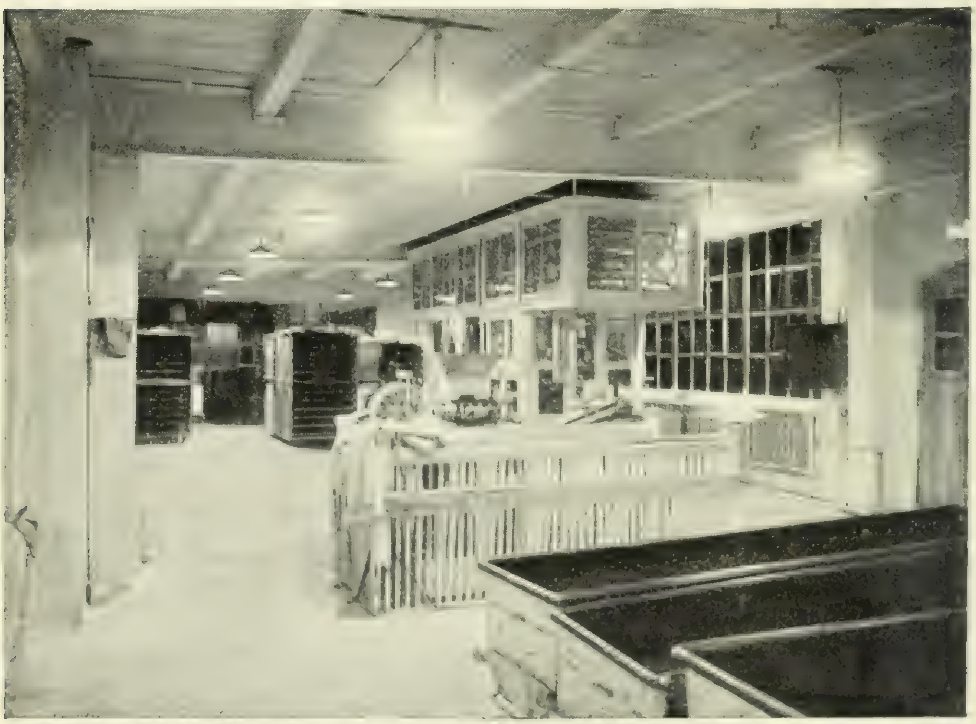

Fig. 8—Night view of dividing and raising room of a well-lighted bread bakery, 100-watt clear Mazda C lamps in RLM standard dome reflectors on 9-foot centers provide a working intensity of 8 ft.-c.

manufacturing pecularities are concerned in an article of this character. It was found, however, that the procedure involved parallels very closely that described in a typical flour mill plus cooking, baking, steaming and the like.[3] Breakfast food manufacturies are usually of standard mill type construction characterized by large window areas producing good daylight conditions. Artificial lighting practice varies widely, although the trend as indicated in new construction is toward high grade general illumination. Many of the older plants inspected were found to be using a haphazard system of B lamps on drop cords, and as a contrast to this were found modern plants at the other extreme using well planned systems of totally indirect lighting.

The following tabulation indicates the recommended lighting practice.

Process or operation	Type of illumination	Intensity ft-c.
Cleaning, grinding, rolling	General	3-6
Baking and roasting	General	5-10

Bakeries.—Bakeries may be grouped with reference to character of product into three general classes, as bread and cake baking, cracker and biscuit baking and pie baking. The establishments of a given group in themselves vary widely in character, from the small cellar or backroom retail variety producing on a small scale and largely by hand, to the huge specially-constructed well-ventilated sunlight factory type building containing acres of floor space and producing enormous volumes by means of highly developed automatic machinery for wholesale distribution.

In bread making the operation consists, broadly speaking,[4] of mixing, raising, dividing or forming, baking and wrapping. In the smaller establishments many of these operations are carried on by hand and wrapping is an unknown quantity. On the other hand, in the large institutions the operations are all carried on by automatic machinery and the product is not touched by human hands from the time the ingredients are mixed until the loaf is placed in the shipping trays.

[3] For a detailed discussion of the processes involved in breakfast food manufacture, see "Food Industries" by Vulté and Vanderbilt, pages 75-80. Publishers, Chemical Publishing Company, Easton, Pa.

[4] For a more detailed discussion of the operations involved in baking see "Food Industries," by Vulté and Vanderbilt, pages 81-116, Publishers, Chemical Publishing Co., Easton, Pa.

Crackers and biscuits are numerous in variety, ranging from the well-known soda cracker to the heavily candied and fruited cracker which might almost be classed as confection. The manufacturing operations in this phase of the industry, in addition to those encountered in bread-making consist of the preparation of fruits, nuts, icings, etc., and the application of these. By far the major part of this class of product is made in huge establishments by automatic and semi-automatic machinery.

Pie baking involves, in addition to the usual blending and mixing processes, the preparation of fillers such as fruits and custards, and their introduction into the molds. Fruit-peeling in some cases is carried on by hand, while in others specially designed machines are utilized. The sorting of fruits, the picking of raisins and similar operations, depend to a considerable extent on the human element, and good lighting is a vital essential in maintaining the product at a high grade.

The survey indicates that the majority of baking establishments are using lighting systems which are far below a satisfactory and economical standard. In fully 50 per cent of the plants inspected reflectors were found to be a practically unknown quantity and vacuum lamps ranging from 25 to 60 watts were the prevailing light sources. Light distribution is an element very seldom found to receive consideration and the prevalence of glare caused by unshielded light sources is almost as universal as the use of electricity as an illuminant itself. Many large and otherwise high-grade modern plants and in fact some even under the course of erection were found to be planning the use of lighting systems which would result in intensities ranging from 1-2 foot-candles. The surroundings in these plants are usually finished in white to promote cleanliness and light utilization as a consequence is fairly good. However, the average run of intensities is from one-half to 2 foot-candles and in line for substantial betterment. (See Figures 7 and 8).

During the course of baking it frequently becomes necessary to observe progress. For this purpose artificial light other than that furnished by an overhead general system is required and several schemes are in vogue. The simplest consists of the use of a low wattage bare lamp mounted on an extention cord which is inserted at the front of the oven when inspection is made.

This scheme, is very poor, inasmuch as the light source is usually in the line of vision and there is a great likelihood of lamp breakage. Another common practice is to mount a bare low wattage lamp in one corner of the oven, occasionally with a reflector behind it, sometimes continuously in circuit and sometimes arranged for plugging in during inspection. Inasmuch as the baking temperature ranges from 500° to 750° F. short lamp life results from such practice, a week or ten days being the average time of satisfactory performance. Although special lamps having special treatment in such matters as glass, basing cement, solder, exhaust, etc., have been developed for use in such locations their life performance is not sufficiently better than that of regular lamps to warrant their adoption.

Several oven manufacturers, apparently realizing the weakness of these makeshift schemes, build special lighting equipment in their ovens. The lamp application in such cases usually takes one of two forms. One arrangement consists of a swinging arm mounted without the oven holding a housing with a glass front a reflector and a 40 or 60-watt Mazda B lamp. This arm may be swung into the oven and light secured over the bake at the time of the inspection. Inasmuch as the oven door cannot be closed when the arm projects through the doorway, the possibility of having the lamp at oven temperature for any appreciable length of time is eliminated.

The other scheme employs a unit which is built in a port in the front oven wall. It consists essentially of a cylindrical shell pivoted at the center one-half being of cast iron and the other mica, with a low wattage lamp and reflector mounted within. Normally the cast iron section faces the interior of the oven, the lamp being on the outside. When inspection is made the cylinder is turned on its axis, by a handle provided for that purpose, and the light thrown where desired. The only fault with this equipment is that the operators in carelessness frequently fail to turn the lamps back to the outside position.

Gas-filled lamps are found to give a better life performance in this service than vacuum lamps.

The following tabulation indicates the recommended standards of illumination for this class of work.

Process or operation	Type of illumination	Intensity ft-c.
Blending	General	4-6
Mixing	General	4-6
Dividing and forming	General	4-6
Fruit sorting and peeling	Localized general	10-15
Raisin picking	Localized general	15-18
Baking	General	4-8
Icing	General	4-8
Wrapping	General	4-6

Canneries.—Canning as an industry in the United States dates back to 1819 when the packing of marine products was undertaken on a small scale on our eastern coast. Western emmigration and the necessities of war caused an enormous expansion in this method of food preservation and to-day it embraces the treatment of a vast array of foodstuffs as fruits, vegetables, meats, marine products, milk and the preparation of many specialties.

Fruits, vegetables and most varieties of canned fish are seasonal products whose production occurs over a very brief period of time. As a consequence in plants handling foods of this kind, it becomes necessary to carry on work almost continuously during the flush season and until the run of raw material is exhausted. The need for high grade artificial light under such conditions is quite obvious.

On the other hand, there are many canneries whose products are of the year round variety as for example, soup, bean and milk canneries and in which working hours are much the same as encountered in the average industry.

Those plants which work but a few months during the year are in most instances crude roomy structures, built solely to offer protection from the elements, while those whose production is of a more constant order are usually housed in substantial buildings of typical factory construction.

The first important operation in canning is that of the grading of raw materials with reference to size and quality.[5] The former discrimination in the case of fruits and some vegetables is made by machines while in the case of most other products this opera-

[5] For a more detailed discussion of the operations involved in modern canning see "Food Industries," Vulté and Vanderbilt, pages 251-262, Publishers, Chemical Publishing Co., Easton, Pa.

tion depends upon human accuracy. Quality grading is undoubtedly one of the most important of processes and depends entirely upon the visual accuracy of the worker.

Other preliminary operations vary widely depending upon the product treated. Some materials require but very little preparation while others must be pitted, cored, peeled, husked, etc. Various methods of accomplishment are employed some utilizing machinery and others depending entirely upon the skill of the worker. Washing, the next operation, is purely mechanical and is followed by blanching or parboiling, can-filling, processing and cooling.

Present day artificial lighting practice in this industry varies widely. Managers of many large modern canneries, realizing the benefits of high intensity properly applied light, have adopted commendable systems to their requirements. In such plants general lighting employing from ¾ to 1 watt per square foot is being used with localized general lighting at preparation tables and can inspection benches. In the small institutions, however, and particularly those who function but a few months a year the lighting application is rather poor and consists for the most part of the indiscriminate application of bare lamps.

In recommending desirable lighting practice for this phase of the food industry too much stress cannot be laid upon the importance of uniform distribution and adequate intensity, particularly in the cutting, peeling and various preparatory operations. Provision must be made so that shadows will not be cast in front of the operators as they sit and cut or sort. The psychological effect of lighting on employees is also an important consideration inasmuch as the majority of workers are women and as commonly known the working efficiency and general welfare of this class of labor is influenced to a marked degree by the working atmosphere. General lighting with localized units at the points previously mentioned, answers all the lighting needs in the canning factory.

In many canneries, as for example, in the canning of peaches, there are as many as five or six distinctive grades of products. In order to discriminate these from the bulk as received, exceptionally good lighting is obviously necessary. Daylight Mazda Lamps are found to be extremely helpful in the discrimination of

color, quality and blemishes, and should be employed where such work is carried on. Accurate color matching units, are also invaluable in the laboratories where color comparisons and tests are made.

The following tabulation indicates the recommended practice for the lighting of canneries.

Process or operation	Type of illumination	Intensity ft-c.
Grading	Localized general (daylight lamps)	10-15
Peeling, pitting, husking, cutting, etc.	Localized general	8-12
Washing	General	4-8
Blanching	General	4-8
Can filling, exhausting and closing	General	4-8
Can inspection	Localized general	10-15
Processing and cooling	General	4-8
Labeling and packing	General	4-6

Meat Packing.—The modern packing plant is a typical example of the great progress that has been made in the scientific handling of foodstuffs during the last score of years. Whereas in time gone by, it was primarily a winter industry, modern methods of refrigeration have made it possible on an enormous scale throughout the entire year. Federal Government inspection has done much toward elevating the standards of working conditions and sanitation. The Bureau of Animal Industry of the U. S. Departmtnt of Agriculture require that complete plans for the new buildings be sent to Washington for examination and approval and their recommendations must be carried out. Regulation No. 8 of the Bureau reads that abundant light both natural and artificial must be furnished at all times and in all places except coolers, curing cellars, etc., although it is advocated that natural light be had here if possible. Painting is also required on all woodwork and must be of a light color so that accumulations of dirt or dust can be readily seen and removed.

A modern establishment of average size is made up of a number of buildings grouped together in a manner best suited for the efficient handling of the various products. Old plants are largely of mill type construction with low ceilings, heavy timbers beams and many columns which tend to obstruct what daylight succeeds in entering through the small unfrequently washed windows. On account of the relatively large floor space,

little daylight penetrates the spaces remote from the windows and artificial light has to be employed at all times. Small interior rooms, curing cellars, coolers, and passageways usually have no provisions for daylighting.

Modern buildings as now constructed under government approval are usually planned so that daylight can penetrate to the maximum depth. This limits the width of the buildings to approximately 80 feet. Construction is usually of the mill type with bays 16 feet by 16 feet.[6] As compared to the older houses, ceilings are usually higher, columns fewer, windows larger and daylight conditions much improved.

The working operations in meat packing consist of slaughtering, removal of hides, pelts or bristles, as the case may be, removal of the internal organs, heads and feet, followed by a thorough scrubbing and washing. The carcasses are then removed to the coolers where they hang until shipped or until they are sent to the cutting department for dissecting preparatory to curing, sausage making or canning.[7]

Although government regulations have done much toward improving sanitary and daylight conditions, artificial lighting in many plants is still far from a satisfactory standard. The equipment in use is of a wide and in many cases antiquated variety. Carbon filament and vacuum lamps are still commonly used while glaring units are very common. In many cases where reflectors are used, they are not of a type designed for the lamps in connection with which they are being operated. Local lighting, employing groups of small bare lamps is frequently used at the cutting tables, etc., the very places where comfortable and adequate light is most essential.

In operations such as the stripping of hides, dressing and inspecting, a comparatively high intensity of well diffused light is absolutely essential, to the maintenance of a high grade of

[6] For a more detailed description of modern packing house construction see "Packing and Cold Storage Construction" by H. Peter Henschien, Publishers, Nickerson and Collins, Chicago, Ill.

[7] For a more detailed discussion of the operations involved in meat packing, see "Food Industries" by Vulté and Vanderbilt, pages [illegible]. Publishers, Chemical Publishing Co., Easton, Pa.

product, the minimization of spoilage and the prevention of accidents such as cuts. (See Figure 9). Sales cooler lighting should be of a comfortable and effective character inasmuch as it is there that the prospective buyers examine the carcasses and make their selections. (See Figure 10). A medium intensity of general light will suffice for most all other working spaces.

The following tabulation indicates the recommended practice for the lighting of packing houses:

Process or operation	Type of illumination	Intensity ft-c.
Slaughtering	General	3-6
Hide stripping and dressing	General	8-12
Washing	General	8-10
Inspection	Localized general	12-14
Cooling	General	4-8
Cutting	Localized general	8-10
Cooking, grinding, sausage stuffing, etc.	General	6-8
Curing		2-4

Ice Cream Manufacturing.—Ice cream frequently termed the "Great American Dessert" was developed as a frozen milk product in northern Italy. The industry is one which has expanded with surprising rapidity, particularly in recent years. In nearly all large cities are found plants both large and small usually of modern factory construction devoting their entire efforts to ice cream production.

The manufacturing consists of the mixing of the ingredients freezing and holding in coolers until shipped.

Lighting practice in this industry is among the poorest found in any of the so-called food industries. Proprietors of some plants attempt to excuse this state of affairs by referring to the seasonal nature of their business but the majority of the plants operate during the hours of darkness as well as light especially during the summer months.

General illumination of a modern intensity answers all lighting demands.

The following tabulation indicates the recommended practice for the lighting of ice cream plants.

Process or operation	Type of illumination	Intensity ft-c.
Mixing	General	4-6
Freezing	General	4-6
Coolers	General	3-4

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Fig. 9.—A night view of the killing and stripping floor of a modern packing plant: 150-watt bowl enameled Mazda C lamps in shallow dome porcelain reflectors on 10-foot centers, assisted by light colored surroundings, furnish a well diffused illumination of approximately 12 ft.-c. intensity.

Fig. 10.—Night view of a typical "Sales Cooler" illuminated by 60-watt bare Mazda B lamps on centers 8 x 6 feet producing an average intensity of 8 ft.-c. The light surroundings aid in the utilization of light and minimization of glare from the unshielded lamps.

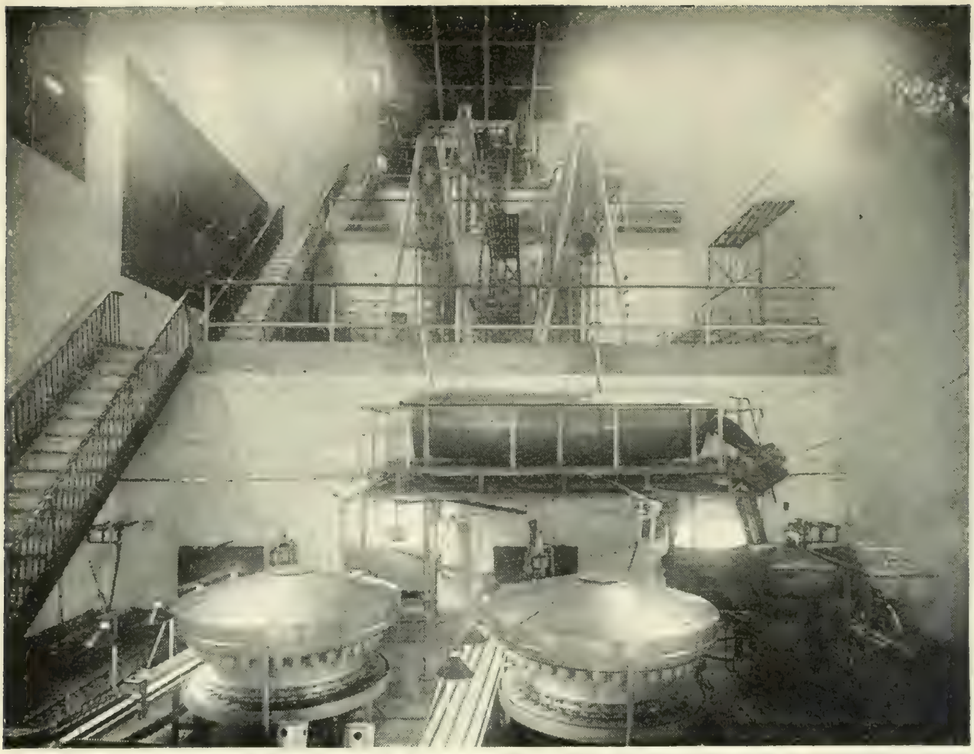

Fig. 11.—Night view of pasteurizing and bottling room in a modern milk treating plant. General lighting of an average intensity of 5 ft.-c. is provided by white tile lined side wall troughs fitted each with four 40-watt lamps. Local lighting of an intensity of 12 ft.-c. for inspection at the take off points on the bottling machine is provided by steel reflectors and 60-watt lamps.

Fig. 12.—Night view of a well lighted shipping platform of a large city milk distributor and pasteurizing plant. An average intensity of 2 ft.-c. is provided by the overhead lighting units.

Chocolate and Candy Manufacture.—The ever growing public demand for sweets has elevated the candy industry from the retail store, basement shop to the modern daylight factory of irreproachable construction though there still remain many of the smaller establishments.

The conversion of cacao bean, as received by the chocolate manufacturer, into the chocolate of commerce involves processes which are known as cleaning and sorting, husking, sieving, and winnowing, milling or grinding, fat extraction, crushing, sifting, mixing, refining, kneading, moulding, setting or cooling and wrapping.[8]

The principal operations in candy making consist of mixing, cooking, moulding, dipping and wrapping.

Lighting conditions in this industry vary widely. Several of the large plants inspected were found to be using admirably applied general illumination with intensities ranging from 4 to 6 foot-candles. Others were found to be using haphazard applications of bare lamps on drop cords and these apparently are still in the majority.

There are no difficult problems involved in the lighting of these factories and general illumination properly applied is usually found well suited to all areas.

The following tabulation indicates the recommended practice for the lighting of chocolate and candy factories:

Process or operation	Type of illumination	Intensity ft c
Chocolate		
Cleaning and sorting	General	4-8
Husking, sieving and winnowing	General	4-8
Milling	General	4-8
Fat extraction	General	4-8
Crushing, sifting, mixing and refining	General	4-8
Kneading and moulding	General	4-8
Setting	General	4-8
Wrapping	General	5-10
Candy		
Mixing	General	4-8
Cooking	General	4-8
Moulding and dipping	General	5-10
Wrapping	General	5-10

Fruit Packing.—As compared with the intricacies of manufacture encountered in many of the food industries, fruit packing

[8] For a detailed description of chocolate manufacture see "Cocoa and Chocolate" by R. Whymper, Publishers, J. A. Churchill, 7 Great Marlborough St., London, England.

is of extreme simplicity. The fruit, upon being harvested, is usually taken either to rudely constructed tables built in the open at a convenient part of the orchard or to more or less substantially constructed sheds for cleaning, grading and in the case of choice fruits, wrapping.

By far the most important operation in fruit packing is that of grading. In the case of apples, pears, peaches, apricots, etc., this consists of the division of the crop into three groups while in some citrus fruits as many as five gradations are made. Classification is carried on with careful reference to size, shape, color, degree of ripeness, blemishes, bruises, etc. Extremely good light of a character enabling fairly accurate color discrimination is highly essential in this work. It is found that most packers depend almost entirely upon north skylight, suspending operations with the coming of darkness and on cloudy or rainy days.

Owing to the short harvest season and relatively high perishability of most fruits the problem of prompt grading is of serious importance. In at least one large California orange and lemon packery a practical solution has been reached by the adoption of proper lighting. The scheme employed involves the use of Daylight Mazda Lamps in deep bowl porcelain, enamel steel reflectors hung 3 feet above the grading tables and producing a uniform intensity of approximately 8 foot-candles. It is claimed that carefully conducted tests show that fruit may be graded under this light with the same degree of accuracy as under normal daylight and further that the workers prefer the artificial illumination.

The introduction of this lighting system has made possible double shift operation and according to the plant manager will make possible the saving of thousands of dollars in plant additions to say nothing of the increasing output and hastening of marketing.

In cleaning and wrapping, a medium intensity of general lighting supplied by standard units, localized with reference to the working tables is found satisfactory.

The following tabulation indicates the recommended lighting practice for fruit packing establishments.

Process or operation	Type of illumination	Intensity ft-c.
Cleaning	Localized general	3-6
Grading	Local	8-12 daylight lamps
Wrapping	Localized general	3-6

Milk Treating.—Milk plays a more important role in the average daily life than any other beverage, usually being found on every table either in its natural, condensed, or evaporated form. Because it becomes easily contaminated, cleanliness is an absolute necessity in its handling and to these ends, good light is an important aid.

Dairying and treating plants are characterized by their clean and light interiors. Walls and ceilings are usually finished with good white paint or white tile and windows and .skylights are liberally provided.

The processes involved in marketing fresh milk may be briefly summarized as pasteurizing, bottling and canning, cooling and shipping.

Pasteurizing is a process of heating and rapidly cooling which results in the destruction of a considerable part of the bacterial life and improvement in the keeping qualities of the milk. It is the most important process encountered in milk handling, and is attended by the greatest of care. Bottling is done by automatic machines, each bottle being inspected after being capped or sealed by an operator who lifts the bottles from the machine and places them on a conveyor on which they are carried to the coolers where they are held until shipped.

General lighting supplemented by local or localized general lighting at inspection points is usually employed in milk treating plants and is well adopted to the work carried on. (See Figure 11).

Inasmuch as most milk shipping especially in the case of city distribution is done during the night or early morning, good shipping platform lighting is important and may usually be obtained by properly applied general lighting. (See Fig. 12).

No particular lighting problems are encountered in condensing or evaporating plants and general lighting of a medium intensity is found to answer all requirements.

The following tabulation indicates the recommended lighting practice for milk treating plants.

Process or operation	Type of illumination	Intensity ft-c.
Pasteurizing, bottling and capping	General	4-8
Bottle inspection	Local or localized general	10-12
Cooling	General	2-4
Can and bottle washing	General	2-4
Shipping	General	1-2
Condensing	General	4-8
Evaporating	General	4-8

CONCLUSION

There are of course, other products whose manufacture falls within the scope of the title of this paper and it is regretted that the limited time available for compilation and preparation has necessitated their omission.

In conclusion it may be justly said that the "Food Industries" present as much and perhaps more room for development from the artificial lighting standpoint than any other industry in the country. They represent a field which has hardly been touched upon and in which the Illuminating Engineer, Lighting Salesman and Central Station can co-operate in carrying on a worthy and profitable campaign of elevation.

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DISCUSSION

L. B. MARKS: I could not help thinking while Mr. Rademacher was talking that twenty-five years ago in the factory lighting industry, we had pretty much the same conditions to contend with. Of course, we still have a great deal to contend with, and the old question of the manufacturer not appreciating what we have to give him is going on and has not been solved, and the best that we can do is to keep on doing what the Society has been doing: educating, educating, educating in all directions.

It does seem a pity that new plants should put in installations giving only one to two foot-candles, where six or eight or ten are required, and it was certainly interesting and delightful to hear the comments made by Mr. Rademacher, and to note that he among others is making progress, real substantial progress, in pointing out to the industry the need of better illumination and the advantages that accrue therefrom.

Incidentally, I might say that the Lighting Committee of the New York State Industrial Board has made a survey of shop lighting, including the lighting of the food industry, and the results of that survey check up very closely with what Mr. Rademacher has reported in his paper. The percentage of bare lamps runs nearly 50 per cent, even after sixteen years of educational work of the Illuminating Engineering Society.

DAVID SPINDELL: The use of prismatic glassware, for upper windows in factories, will greatly increase the distribution of natural light, and permit the use of the lower windows for viewing objects.

NORMAN MACBETH: I have come across one or two interesting points in the food industries in the use of artificial daylighting equipment that I thought might be of interest, as Mr. Rademacher has made certain references to that kind of equipment.

In milk plants we found instances where yellow stains on the inside of milk bottles had withstood all ordinary washing and sterilizing and could not be seen under artificial light; the bottles were filled with milk, and the next morning on the back porch they would show up the yellow stains against the background of the milk. It requires either natural daylight or an artificial daylight of reasonably exact reproduction to show up these yellow stains.

We also had an interesting application a short time ago from a fish-packing plant in New England. It seems that in taking the cured codfish and cutting it up for packing in boxes occasionally the knife would cut into a worm, and this particular packing concern took pride in their product and desired to get rid of those worms. The only way they could find the worm in the cured side of a codfish was to hold the fish up against a bright sky background, the selective absorption of the worm being slightly different than the fish, and they could lay the fish on the table and dig the worm out. They desired to save the workmen the trouble of turning around to examine each fish at a window, many of them had to make a full half-turn to get to a window, and at the same time there were days when the sky brightness was not sufficient. So artificial light was resorted to; they cut a hole in the table, put a piece of plate glass over it, and tried a 200-watt lamp and an RLM reflector underneath it. Two things developed. The first was that under artificial light the worm disappeared and became the same color as the codfish, you could not see it; the second was that the glass got so hot and the glare from the lamp was so serious that this scheme failed.

In taking up that application, we had occasion to use a 500-watt lamp with a filter for the reproduction of daylight, and we practically eliminated heat and glare with a momentary contact foot operated switch, so that the lamp was only on during that period when the operator had the fish on the table, cutting out the worms. In between times, while cutting up the side of the fish, the lamps was off.

It should be understood that the worm is part of the codfish, but when the housewife finds it she is under the impression that it is an improperly cured codfish which has been neglected somewhere in the process and some outside creature has gotten in. These worms are actually taken up by the codfish in their natural living condition when they are lying around on the rocks in shallow water; they become attached to the fish and afterwards enter. They are a perfectly good kind of codfish worms, so that it does not mean bad codfish if you get this kind of worm in it.

We also found an interesting application in the large bakeshops and in flour mills. Your flour is graded in terms of your com-

petitor's flour. There is a day-to-day standard. The mills handling a high grade of flour will have samples of several competing flours, all in similar bins, the bins replenished regularly with flour of the same manufacture, and each day they bake sample loaves from each blended brand, but the loaves baked to-day are of no value in comparison with those baked yesterday. It is the flour and loaves that are baked to-day that must be compared because of the humidity, air conditions and similar factors. Color is exceedingly important because there is a difference in sales value if the flour is slightly off the white, so a very accurate daylight is necessary for grading in locations and at hours when natural daylight is absent or of poor quality.

G. H. STICKNEY: One interesting feature of Mr. Rademacher's investigation, which we have frequently found before, is that the visit of investigation had a tendency to bring the question of better lighting more specifically to the attention of the management.

Even when they explain why something better is not needed, the fact that their present practice requires defense, is likely to create a stronger desire for better lighting. At any rate, inquiries and improvements do follow in the wake of such investigations, indicating that they have a value in addition to yielding the data sought.

E. B. FOX: There is just one point I want to bring out on this question of enclosing unit. Mr. Rademacher said in all cases that these units should be vapor-proof. Lately we have been doing some experimental work, and I think that it would be better to say they should be dust-proof in grain elevators, because although at the present time all the units on the market are vapor-proof, it is possible that in the future, in order to obtain better lighting, something may be developed in the way of an RLM reflector, or other unit with a large surface, having a piece of wire glass clamped over its opening. It would be very difficult to make such a unit vapor-proof, and vapor-proof units are really not necessary in grain elevators.

As to the question of temperature, in grain elevators it is of course necessary to keep the temperature of the unit below the ignition temperature of the grain dust, but this ignition temperature of the dust is quite high. There are none of the grain dusts

that will ignite much below 500° F., and none of the vapor-proof units on the market are running above 250° F. if they are used with the lamps designed for them. However, in order to keep the temperature of new units down, there must be a large radiating surface, and that is the thing that must be watched, because it is impossible to cool the units by putting in ventilating holes if it is to be kept dust-proof.

W. H. RADEMACHER: I do not think there is much I can add to what has been said. I do think the points mentioned are all very well taken.

In reference to the first question that was raised, in connection with the use of prismatic or ribbed glass in the upper half of factory windows, I believe it is generally conceded that it is good policy to use such glass where you have a comparatively wide floor area and where you want to throw light rays toward the center of the room and tend to even out your daylight distribution.

Mr. Macbeth's points in reference to daylight lamps in the food industry are very well taken. I think there are a good many places where daylight lamps are not being used at the present time as extensively as desirable—the fruit packing industry being one of them—where better work can be done, where production can be speeded up and quality made more uniform by their usage.

With regard to the use of vapor-proof globes in flour mill and grain elevator lighting, I agree with Mr. Fox, in that if a unit is developed which is satisfactory from the standpoint of temperature and also satisfactory from the standpoint of prevention of dust getting in to the lamps where it is going to be dangerous; it would be all right, if the unit was not vapor-proof but was dust-proof.

COTTON MILL LIGHTING*

BY JAMES M. KETCH**

SYNOPSIS: Whereas general lighting is easily applied to the usual industry it is necessary in lighting cotton mills to take account of the long rows of high machines. However, the grouping of machines is almost uniform in the average cotton mill; small looms will generally be found in groups of four, spinning frames arranged four rows to the average bay width, and cards arranged side by side with work-aisles at each end of the machines.

It is important that the lighting be so arranged that each work surface will receive light from the proper direction. This makes it necessary that the luminaires be grouped with respect to the machine arrangement rather than with respect to the bay dimensions. The general acceptance of the RLM dome and bowl-enameled lamp by cotton mill engineers and architects makes it possible to suggest standard lighting designs which fill the requirements of practically all cotton mill processes. A number of such standard group lighting designs are discussed in this paper.

In contrast to the commendable standardization of cotton mill building and machinery arrangement, until recently there has been little attention given to the possibilities of standardization in lighting; that is, levels of illumination, arrangements of lighting units, and the adoption of standard reflectors and lamps. The more rapid strides made in lamp manufacture as compared with the development of suitable reflectors, explains the temporary dissatisfaction some mills experienced in their early attempts to use the highly efficient Mazda C or gas-filled lamps. With the reflectors available at the time Mazda C lamps were introduced and following for a time thereafter, there seemed to be only three solutions to the lighting problem; to use (1) the old shallow dome, which caused glare when used with Mazda C lamps; or (2) the deep bowl, which while eliminating direct glare, had certain disadvantages; or (3) lower wattage Mazda B lamps, which while having a lower filament brightness, operated at a lower efficiency.

In time reflectors were developed which effectively combined glare protection and ecomony in such a way that the safe use of Mazda C lamps became possible. Undoubtedly, the most im-

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**Engineering Department, National Lamp Works of G. E. Co., Cleveland, Ohio.

portant steps facilitating standardization in lighting have been the recent development of the bowl-enameled Mazda C lamp and the RLM (Reflector and Lamp Manufacturers) standard dome reflector. This reflector and lamp combination permits the standardization of cotton mill lighting to a degree not possible before.

REQUIREMENTS OF GOOD ILLUMINATION

The six prime requirements which a satisfactory cotton mill lighting installation must fill are:

1. Adequate illumination on the work;
2. Freedom from objectionable shadows;
3. Freedom from glare;
4. Light from the proper directions;
5. Light of the proper color quality;
6. Sufficient light on ceiling and walls to make the interior bright and cheerful.

Foot-Candles of Illumination—Problems of power analysis are now figured from effect to cause,—from yards per day to the power required,—rather than by assuming that there is a definite amount of power available which must be equally divided between machines. The illumination problem should receive the same sequence of attack that a power problem does. The modern procedure in designing an illumination system is to start with the effect desired and knowing that a certain foot-candle level of illumination is needed for the operation, select the most economical spacing, the best type of lamp, and the proper reflector for it.

Individual engineers and architects who design cotton mills and illumination systems have standarized on levels of illumination which conform very closely to those recommended in some of the more recent state lighting codes. The levels which have been adopted by a number of prominent cotton mill engineers and architects are shown in Table I.

As shown by the table, the average levels of illumination for the coarser operations before the yarn has become drawn fine, are 3½ to 7 foot-candles. The finer operations involving the working of drawn and spun yarn require levels ranging from 5 to 8 foot-candles or more. It is reasonable to expect that, as a general rule, the finer or darker the material worked, the higher the required level of illumination. For example, a damask or plaid

TABLE I—Foot-candles Adopted by Prominent Cotton Mill Engineers

Engineering firm	Opening Picking Carding Dyeing Lapping	Drawing Roving Speeders Slubbers	Spinning Twisting Warping Beaming Quilling	Weaving Inspecting Finishing
A	4-5	5-6	6-7	6-7
B	6-9	6-9	6-9	6-9
C	5	5-7	7-9	7-9
D	4-5	5-6	6-7	6-7
E	2-6	3-9	3-9	3-9
F	3½-4½	4-5	5-6	5-6
G	3½-4	4-4½	6	6-7
H	2-6	3-9	3-9	3-9
I	2-6	3-9	3-9	3-9
J	2-6	3-9	3-9	3-9
K	5-5½	5-6	6-7½	6-9
Mean	3½-5½	4-7	5-8	5-8

mill may require 6 foot-candles of illumination for carding, roving, and intermediates, and 9 foot-candles for spinning and weaving, but the same operations in a gunny-cloth mill would require only 4 foot-candles and 6 foot-candles, respectively, for corresponding operations.

Mills manufacturing dark cloth and yarn will require the higher recommended levels of illumination for any operation rather than the lower. This applies especially to the finer operations after the yarn has been dyed, such as spinning, weaving, and inspecting, or the rough operations in those mills working cotton which is dyed in the stock.

Shadows—One of the important items that marks the illumination in a mill as good, bad, or indifferent, is the character of the shadows.

Dense, sharp shadows are a prolific cause of industrial accidents. Shadows hide an object to be stumbled over—they may harbor a pair of revolving gears or a set-screw head to catch loose clothing or one's hair. Serious and fatal accidents are probably lower in cotton mills than in any other industry of equal import-

ance, but as long as the mill superintendents' offices need to be equipped with Red Cross emergency kits, and as long as these small, time-losing, near serious accidents continue, it is certainly worth while to provide that quality and quantity of illumination which will minimize every possibility of accident or injury.

The use of plenty of good white paint will go a long way toward eliminating harsh, dark shadows, and will materially assist in utilizing the most illumination possible for a certain expenditure of wattage in a lighting system, or the utilization of a given amount of daylight. In this respect, the cotton industry is to be commended; white paint is plentifully used and the color is generally well maintained; in addition to this, windows are in evidence in proportions found in no industry of like importance. There are few cotton mills, however, where daylight is sufficient in all parts of the mill even on the brightest days. The center aisles in a card room, in the speeder section, and in the spinning room, and the looms in the center of a weave room very often have shadows on the work, and seldom have sufficient illumination from daylight alone. The operators of these inside machines should have the same chance to turn out a perfect product as the more fortunate employees on the machines nearer the windows.

Shadows cast from a large source of light are much softer and more luminous than those from a small source. Accordingly the shadows resulting from the use of a 200-watt bowl-enameled Mazda C lamp in a 16-inch RLM dome will be softer and less confusing than those from a deep bowl with a clear lamp, in which the small bare filament and small reflector diameter combine to make the shadows sharp and dense.

Large Mazda lamps are more efficient in light output per watt expended than small ones. On the other hand, shadows are minimized by the use of several small lamps in place of one large one. A proper balance of these factors applicable to textile mill illumination points to the use of Mazda C lamps of 100, 150, and 200-watt sizes on an average spacing of 10 to 16 feet as the combination which gives the best results in illumination economy as well as shadow elimination.

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Fig. 1.—Picker room lighting. Photograph by courtesy of J. E. Sirrine.

Fig. 2.—Proper lighting in this spinning room is furnished by 200-watt bowl enameled Mazda C lamps in RLM standard domes on a 12½ x 16 foot spacing.

Fig. 3.—A card room with plenty of light in all work-aisles and between the machines, furnished by 150-watt bowl-enameled lamps on a spacing similar to that shown in Fig. 10.

Fig. 4.—Warping requires a high level of well diffused illumination both at the beam and the creel. One hundred and fifty-watt units are spaced according to the suggestions of Fig. 16.

Glare—Glare, loosely defined as "light out of place," is the most frequent and serious cause of bad lighting. It results from the use of bare lamps, or from clear lamps in reflectors which do not have a sufficient shielding angle.

The degree to which glare becomes objectionable depends upon five principal factors:

1. Intrinsic brilliancy of the source;
2. Total candlepower coming from the source in the direction of the eye;
3. Distance from the source to the eye; and position of the source in the field of view;
4. Contrast in brightness between the light source and the working surfaces and surroundings;
5. Length of time during which the source of glare is present within the field of vision.

There are, of course, several means by which the most objectionable glare can be prevented. One of the best is to install Mazda C lamps of the medium sizes, 75 to 200-watt, and to shield the filaments by good reflecting or diffusing equipment mounted 10 feet or more above the floor.

The judicious use of white or light cream paint will assist in eliminating harsh contrasts in brightness between the light source and the working surfaces and surroundings. In mills manufacturing dark materials, there is very little light reflected from the work to the ceiling; in these, the contrast between the lighting unit and the ceiling can be controlled by using reflectors which direct a small part of the light to the ceiling.

One of the most common examples of unnoticed bad lighting is that from the average window. Those operations which require employees to stay in one place for any great length of time, such as drawing-in, warping, and beaming, should be so arranged that the employees may work with their backs to the windows. This not only saves the operators' eyes from glare, but puts a much better daylight illumination on the work. Artificial lighting units for these operations may be easily located where they will be well out of the direct field of vision and will duplicate the natural daylight in direction.

Direction of Light—In the usual industrial operations, the greater part of the surfaces to be lighted are in the horizontal plane. This is only partly true in cotton manufacturing for although the important working surfaces in the carding room, weave room, and cloth room are horizontal, the chief planes of work in the spinning, twisting, and drawing-in processes are vertical. Because of the diversified requirements which obtain in a cotton mill, it is very desirable to select a unit which has a good balance in illuminating efficiency on both horizontal and vertical planes and also to allow due weight to softening of shadows and protection from glare.

When incandescent lamps were first used in cotton mills, the available reflectors were far from satisfactory, and it was found necessary to hang the lamps low on drop cords, and use a large number of small bare local lamps in every work-aisle in order that sufficient light might be obtained on vertical surfaces. This practice was generally uneconomical, and in addition to the prevalence of glare, the illumination was likely to be uneven and spotty because of the tendency to space the units too far apart. As well designed reflecting equipment for use with the higher efficiency Mazda C lamps became available, general lighting systems came into use; the larger lamps were mounted well above the plane of work on a wider spacing, and arranged symmetrically with respect to the building bays. General lighting is used for the average industry to-day. In textile mill illumination, however, additional provision must be made to light special work surfaces. This calls for an arrangement of the lighting system called "group lighting." In this type of lighting, the units, using medium sizes of Mazda lamps, are spaced with particular attention to work aisles or groups of machines rather than symmetrically with the building dimensions, and are mounted 10 to 16 feet above the floor, as in general lighting systems. At the end of this paper are illustrations of standard group-lighting arrangements adapted to the more important mill operations.

Color Quality of Light—Modern research[1] has found that the eye functions at its highest efficiency when the light is most

[1] Ferree and Rand, TRANS. OF THE ILLUMINATING ENGINEERING SOCIETY, Vol. XVII, No. 2, Page 69.

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Fig. 5.—Before and after lighting in a weave room. Two hundred-watt bowl enameled lamps in RLM domes on a 12½ x 12 foot spacing replace 60 and 75 watt lamps in deep bowl reflectors.

Fig 6.—Lighting a finishing roving section. Photograph by courtesy of J. E. Sirrine.

Fig. 7.—Reflector and Lamp Manufacturers Standard Dome.

nearly like daylight. The human eye has also learned to judge colors under daylight illumination, and where color discrimination is needed in colored goods, plaid, and denim mills, a daylight quality of illumination will be found very desirable. When yarn colors are viewed under a daylight quality of artificial illumination, they appear to be of the same color as thought they were observed under a sky-light or near the window. Broken warp which must be replaced in a loom will then always be replaced with warp of the same color, where otherwise this is difficult. Daylight Mazda lamps assist greatly in color discrimination, but are not to be depended upon for accurately matching close color tints.

Cotton grading, one of the important operations in the average cotton mill, is the only means by which the buyer knows whether or not he is getting cotton of the proper length and color. The original standard samples by which cotton is graded were selected under north sky light conditions, and if a true color match is desired, this same quality of illumination must be duplicated when new cotton is matched against these standards. Here, accurate color matching units, of which a number are available, should be used. These units are also found useful in the matching room of knitting mills where quality hosiery is graded as to color into pairs.

Bright Ceilings—The white materials and rolls of cotton in a white or gray goods mill reflect sufficient light to the ceiling to make the room cheerful even though the reflectors themselves do not direct any light above the horizontal. In such locations, the RLM standard dome with diffusing bulb or bowl-enameled lamp represents good practice. There are rooms, however, containing dark materials and machines where some other provision should be made for brightening the ceilings. Gloomy interiors often found in plaid, denim, and cheviot mills may be made more workable and cheerful by the use of plenty of white paint on the upper side-walls and ceilings, and by using a type of reflector which has an upward component of light.

Glass units such as the dense opal bowl, or the prismatic-glass types allow a portion of the light to go to the ceiling. Where the use of porcelain enameled steel reflectors is considered desirable

in dark surroundings, the glass-top dome or the combination glass and steel unit should be used. In these a small opal cap or glass panel is substituted for a portion of the reflector near the holder; either will allow a small, but ample, quantity of the light to be transmitted upward.

THE PROPER USE OF MAZDA LAMPS

The same principles which govern the selection of lamps in other industries apply as well to the lighting of cotton mills. Clear lamps should never be used at mounting heights less than 20 feet where the filaments are exposed to view. The 50 and 75-watt diffusing bulb lamps and the 100-watt and larger with the bowl-enameled bulb are satisfactory in equipments which provide a shielding angle equivalent to that of the RLM standard dome.

Voltage Regulation—Electric power for many cotton mills is transmitted from a long distance, and comes into the mill only roughly regulated. In such cases, the power company or central station selling the power generally makes a paragraph provision in their contract with the mill, that where the power is to be used for lighting purposes, the mill owners are to install adequate regulating equipment at their own expense. These regulators are commonly made to correct any voltage variation between the limits of 10 per cent above and 10 per cent below normal value, thus covering a total voltage fluctuation of 20 per cent.

For the best operation, lighting and power loads should be carried on separate circuits. Not only are voltage fluctuations caused by the starting and stopping of looms and warpers, and the starting of motors thereby confined mainly to the power circuit and the harmful effects upon lamp performance thus reduced, but with such an arrangement, a shut down in the power circuit will not cut off the illumination of the mill at a crucial time when light is needed for repairs.

Wiring—It will be found that cheaply wired mills often have wire of insufficient size or capacity installed, with constantly decreasing voltage from socket to socket along the line. Under such conditions, uniform performance of lamps cannot be obtained.

Excessive voltage drop may sometimes be remedied by making additional cuts in the long circuits and running in heavier feed wires to the centers of the new circuits.

When a mill is rewired or rebuilt, it will be found most economical in the end to employ wire of a size and capacity that will limit the voltage drop from switchboard to circuit ends, to a maximum of 2 per cent. The present high standards of lighting as compared to those of a few years ago are largely due to a better appreciation of the value and advantages accompanying a high level of well diffused illumination. Accordingly, it is well in designing the wiring for an illumination system, to make a far provision for future possible increases in wattage by using wire sufficiently large to accommodate the ultimate future load. Over a period of years, oversize wire is an economy in the same class with oversize tires and oversize motors.

At all times, lamps should be specified of such a voltage as to approximate the average voltage measured at the centers of the circuits in the distribution system under load conditions.

THE ECONOMICS OF A LIGHTING SYSTEM

Switching Groups—Some artificial light is usually needed during the day in the center aisle of carding, spinning, twisting, and weaving rooms, especially in wide buildings of two stories or more in which the work-aisles run lengthwise of the room. Convenient switching groups will allow the dark aisles to be flooded with light while the aisles near the windows are left to the daylight. It is the most reasonable and economical practice to have switch-controlled groups of units in strings parallel to the rows of windows, and parallel to the work-aisles. Fading daylight can then be compensated for by turning on rows of units nearer and nearer to the windows as the condition of the natural lighting dictates.

Methods of Suspension—The day of open wiring and drop cords is passing, and mill owners are installing their wiring in the more modern conduit construction and using some form of conduit suspension. Conduit installations are permanent, economical, and well appearing, and in addition to being required in some cities, always tend to lower the insurance rates on buildings. However, this form of construction may make necessary

added precaution against lamp filament breakage. It is evident that rigid conduit suspensions will neither absorb shocks as well as flexible drop cords, nor will they allow the reflector to swing when it is struck as with a belt or when the walls and ceilings are being swept down.

Several methods of suspension are being used in which rigid conduit is employed, and yet approximately the flexibility of drop cords is retained. One common method is to fasten the reflector to a short piece of conduit having a loop hickey at the top which is suspended from a hook in the ceiling. In others, fixture joints are used which act somewhat like a universal joint in that they allow the conduit to hang vertically, and due to the construction, absorb as much vibration as the hickey and hook arrangement. These latter have the added advantage that the wires are enclosed and carried through the joints for protection.

Maintenance—The proper maintenance of the lighting system in a cotton mill or knitting mill is of very great importance and should receive the serious consideration of every superintendent. It is good practice to select reflectors which are easy to maintain and which have their important reflecting or transmitting surfaces of a shape that minimizes the collection of lint or dirt.

Periodic foot-candle readings taken at test stations throughout the mill, when recorded in such a way as to make them comparative, will serve as an index of the performance and will immediately locate weak points of the system.

It is more economical to institute a regular system of cleaning and maintenance than to allow for a very heavy depreciation in the original installation by the use of higher wattage lamps.

Many mills have a compressed air system available. It has been suggested that the compressed air nozzle can be directed into each of the reflectors each time the walls and ceiling are swept down. This would loosen the light accumulation of lint from the reflector and lamp surface and materially assist in keeping the installation operating at good efficiency. However, this practice would not keep the units clean over a long period of time and a program including washing at intervals is needed. Experience has shown that it is better to wash the lamps and reflectors, than just to wipe them out with a dry cloth.

When compressed air is not available, the mill superintendent should adopt some such cleaning schedule as given in Table II.

TABLE II.—SUGGESTED CLEANING SCHEDULES

Location or process	Interval in days if units are wiped out*	Interval in days if units are thoroughly washed
Picker room	7	10
Card room	7	10
Spinning room	7	10
Spooling	7	10
Twisting	7	10
Warping	7	10
Cloth room	15	20
Office bldg. (Separate from mill)	30	40

*Washing every third or fourth interval assumed.

STANDARDIZED ILLUMINATION

Standarized illumination has followed close on the development of such standarized lighting equipment as the RLM Standard dome and the bowl-enameled Mazda C lamp. All of the following group lighting designs are based on the use of the RLM dome and bowl-enameled Mazda C lamp, because this combination has been largely adopted after thorough trials by textile engineers, architects and illuminating engineers. Other reflectors according to their efficiencies and the manner in which they distribute the light, will give illumination values slightly above or below the foot-candle values obtained through the use of the RLM dome.

Where it is desired to employ Mazda daylight lamps, the wattage should be increased approximately 50 per cent above the values given for bowl-enameled lamps. This corresponds roughly to using the next larger size of daylight lamp. Bowl frosted, rather than bowl-enameled daylight lamps, should be employed because of the heavy losses accompanying the use of bowl-enameled colored lamps.

All calculations of illumination are based on data presented in National Lamp Works Bulletin No. 41, "Illumination Design Data;" accepted allowances have been made for depreciation.

Bale-Breaker, Opener, Picker Room—The rough operations of breaking up the cotton as it comes from the bale, cleaning out the worst of the dirt, and lapping into one sheet of fairly clean cotton, do not demand the same fine quality of illumination found desirable for the subsequent operations. An illumination system designed to provide 4 to 6 foot-candles is considered sufficient. However, it is the practice of some engineers to recommend the same quality and quantity of illumination in the breaker and picker room as in other rooms in order that the same general cheerful atmosphere may be maintained throughout the mill. Since the machines in these rooms are relatively few in comparison with the numbers found in the rest of the mill, there is no plan of machine grouping which may be considered standard. Where there are many of these machines in one room such as is the case in a few very large mills, it is good practice to locate a row of units in each work-aisle between the ends of the machines. This insures that each end of each machine will be lighted. An average spacing of the rows would be between 12 and 16 feet. Where the rows are 12 feet apart, the reflectors should be mounted at least 11 feet above the floor; where the rows are spaced on 16-foot centers, the reflectors should be approximately 14 feet above the floor. In an ordinary picker room, the average illumination values which will be obtained by using the RLM dome and bowl-enameled Mazda C lamp with some of the standard spacing arrangements, are as given in Table III.

TABLE III.—Average Foot-Candles Obtained in a Picker Room With 150 and 200-watt Units at Common Spacing Distances

Reflector spacing feet	Average foot candle 150-watt	Illumination 200-watt
12 x 12	5.5	8.0
12 x 14	4.5	7.0
12 x 16	4.0	6.0
14 x 14	4.0	6.0
14 x 16	—	5.0
16 x 16	—	4.5

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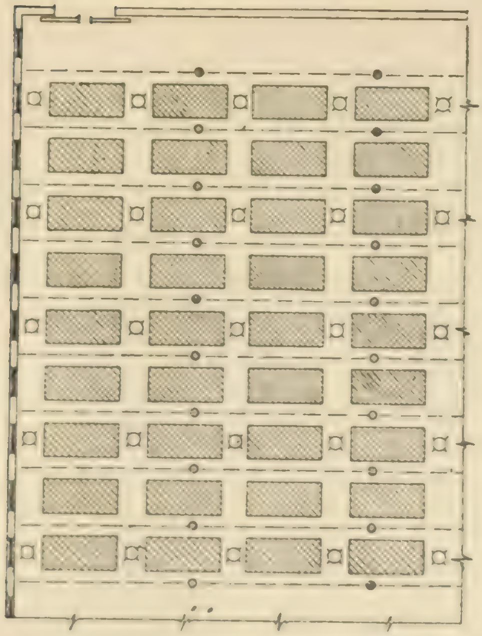
Fig. 8.—This denim weave room uses one 75-watt lamp in an RLM dome for each loom.

Fig. 9.—Lighting in the twisting room. Photograph by courtesy of J. E. Sirrine.



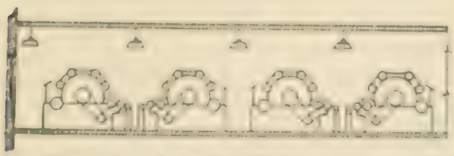


Fig. 10.—A typical arrangement of the lighting units in a card room. The foot-candle values shown in Table IV apply to this room.

Carding—In the carding department, where the individual cotton fibers are straightened and the finer dirt is removed, the visual requirements are slightly higher than in the picker room, and in addition, the speed and operation of the cards is of a nature to cause more accidents than any other mill work. For these reasons, and for convenience in repairing the machines, the reflectors should be so spaced that there will be plenty of well diffused illumination between the machines. Every work-aisle, including the lap and the sliver delivery end of the card, and the aisles on the outside rows next to the walls, should have a row of lighting units spaced 12 to 16 feet apart. An illumination level of 4 to 6 foot-candles is desirable. A sensible arrangement which is adaptable to the average mill is shown in Fig. 10. Table IV indicates the proper size of lamp to use.

Drawing, Slubbers—The drawing frames which draw out the fibers of the cotton and make them parallel, and the slubbers on which these cotton slivers are wound on bobbins, are ordinarily located between the carding section and the fine roving machines. Up to this point, the cotton has not been reduced to a fine strand, and therefore, there is no need for lighting of any better quality than that furnished for the carding. The machines are not very high, and but little trouble is experienced from shadows. It is common practice to adopt the same spacing and reflectors used for carding to the drawing frames and the slubbers. Sometimes lighting similar to that used in the fine roving section is used for these machines. Either system will do.

TABLE IV.—AVERAGE FOOT-CANDLE VALUES RESULTING FROM DESIGNS SHOWN IN FIGS. 10, 11, 12, 13, 18 AND 19. THESE VALUES ARE BASED ON DATA IN NATIONAL LAMP WORKS BULLETIN NO. 41; ALLOWANCES HAVE BEEN MADE FOR DEPRECIATION WHEN RLM DOMES AND BOWL-ENAMELED MAZDA C LAMPS ARE USED

Spacing along work-aisles. Feet	Spacing between work-aisles containing rows of units, feet	Square feet per outlet	Minimum height above floor. Feet	Lamp watts per outlet	Foot-candles, average sustained*
				100	4
10	12½	125	12	150	6½
				200	10
				100	3½
12	12½	150	12	150	5½
				200	8
				100	3
14	12½	175	13	150	4½
				200	7
				150	4
16	12½	200	14	200	6

*When daylight lamps are used, approximately these same foot-candle values may be obtained by employing bowl-frosted daylight lamps of a size next larger than the specified bowl-enameled lamp size.

Roving (Intermediate, Fine Frame, Jack Frame)—Roving machines are high, and are commonly placed back to back forming a narrow back-aisle, and face to face, making a work-aisle. The lighting requirements become more and more exacting in these fine roving processes, since the cotton roving is twisted and

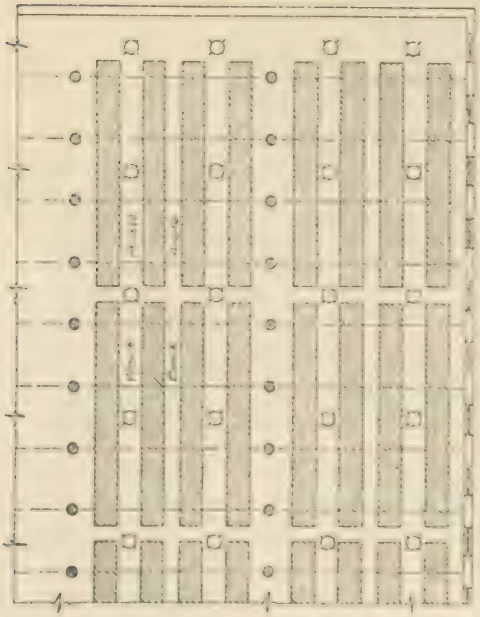


Fig. 11.—A typical arrangement of lighting units for roving frames.

drawn smaller in each succeeding frame. The spindles also operate at increasing speed. The usual practice is to provide good illumination in the work-aisles, and to make no extra provision for the back-aisles. Good illumination for these machines is 5 to 7 foot-candles. A good arrangement of units is shown in Fig. 11. Table IV will show the size lamp to use.

Ring Spinning, Twisting—By the time the cotton has reached the spinning room, it has been drawn and twisted to a fairly small diameter and is ready for the final spinning. Here good vision and plenty of illumination is needed for properly watching the bobbins to see that none are running idle with the yarn broken. Both sides of the spinning and twisting frames are work faces; this requires that the outside aisles next to the walls be provided with the same illumination as the inside aisles. The general practice is to begin with the outside work-aisles next to the wall and to place rows of lighting units in alternate work-aisles. The reflectors in each row should be spaced 10 to 16 feet apart. An illumination of 6 to 9 foot-candles for undyed yarns, and 9 to 12 foot-candles for dyed or mixed yarns, is recommended. Two

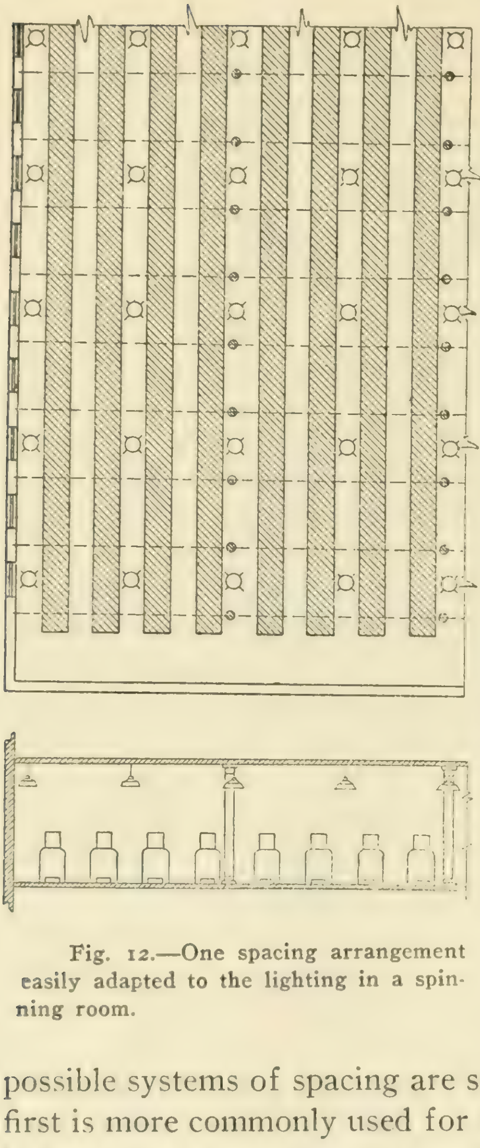


Fig. 12.—One spacing arrangement easily adapted to the lighting in a spinning room.

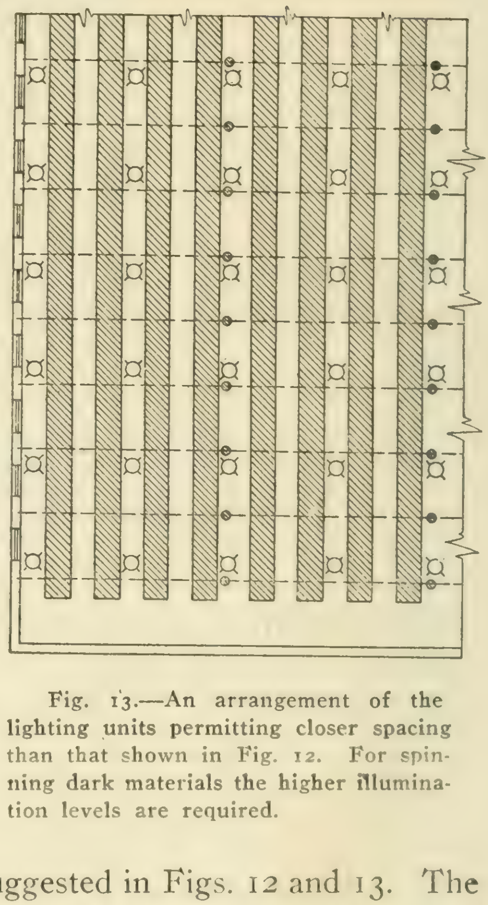


Fig. 13.—An arrangement of the lighting units permitting closer spacing than that shown in Fig. 12. For spinning dark materials the higher illumination levels are required.

possible systems of spacing are suggested in Figs. 12 and 13. The first is more commonly used for undyed yarn spinning; the second is sometimes convenient where higher values of illumination are desired, or where the spacing between columns is more than the usual 8 feet. By having rows of reflectors in alternate aisles, light reaches all of the working surfaces, as shown in Fig 14. The proper lamp may be determined by consulting Table IV.

Spooling, Winding—Spooling sections ordinarily occupy a small part of the mill space. Any system which gives satisfactory illumination for spinning will also satisfy the requirements for spooling or winding.

Warping—In warping, it is best to have plenty of well diffused illumination at both the creel and the beam. The warp, which is being wound from the spool on the V-creel upon the section beam,

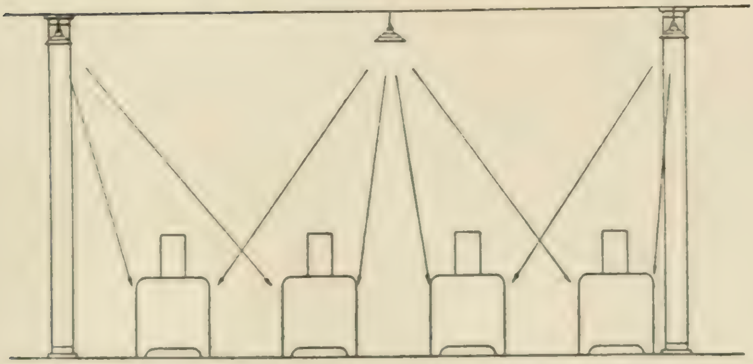


Fig. 14.—The light reaches all working surfaces of the spinning and twisting frames where rows of units are placed in alternate work-aisles.

has been spun to its final small size and twist, and the visual requirements are necessarily exacting when an operator follows a broken thread from the beam to the creel. An illumination of 6 to 9 foot-candles is good practice. The row of reflectors at the beam end should be about in line with the beam, and between the individual machines. The all-too-common practice of putting the reflectors directly behind the machines instead of between them, causes the operator to work in his own light when he ties a broken warp. A good arrangement for a warping section is shown in Fig. 16.

Slashing—The best illumination for slashing or warp-sizing is needed at the head end of the slasher, between the combs and the beam. A 100 or 150-watt bowl-enameled Mazda C lamp in a standard RLM dome may be hung 4 to 6 feet above the warp at the place where it is most needed. In case colored warp is being sized, the 150 watt unit is needed, and if the warp is dark blue or black, a 200-watt unit over each slasher at this point is not extravagant. General illumination on the spacings recommended for carding will do very well for the creel end of the slasher. It should be remembered that light is desirable between all of the individual machines. Since the starch boxes are inspected at frequent intervals, provision should be made for a local light extension under the hood. A satisfactory arrangement is illustrated in Fig. 17.

Weaving—Good illumination is of great importance in the weave room, because it is here that the weavers actually combine the warp and filling to make cloth, and it is here that good light

and good vision are needed to maintain the quality of the cloth. Poor workmanship in the weave room results in more financial loss than in any other part of the mill. The weave room illumination should be well balanced as to horizontal and vertical values; illumination on horizontal planes is needed for cloth inspection, and illumination on vertical surfaces is very essential for the process of threading a broken warp through the harness wire.

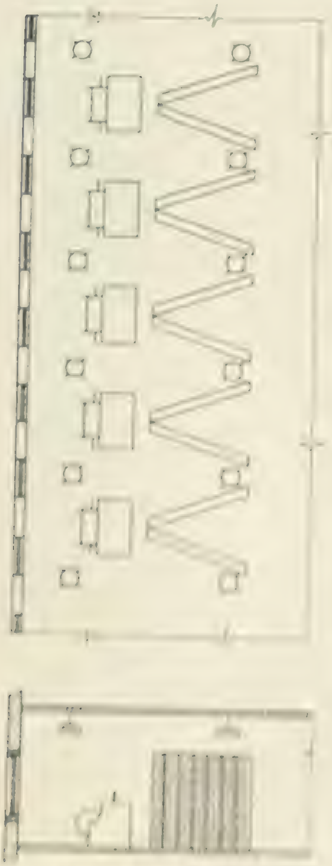
The arrangement, mounting height, and type of reflectors should be such that the back of the looms will be almost as well lighted as the front. In the past, when certain concentrating types of reflectors on low mounting heights were used, it was necessary to put rows of units in the back-aisles as well as in the work-aisles. However, with most of the present day reflectors, the light is distributed rather than concentrated. By using reflectors having a wide spread of light and properly spacing them, both the work-aisles where the reflectors are placed and the backs of the looms in adjacent back-aisles may be adequately lighted by single rows of units over the work-aisles.

A common arrangement of small looms is in groups of four. Ordinarily, these groups are placed so that one unit, such as the RLM dome and bowl-enameled lamp, for each group, Fig. 18, provides good illumination in both the work-aisles and back-aisles. The mistake is often made of putting lighting units directly in front of the looms in the work-aisles, thus placing the source of light in a position where shadows will be cast by the weaver as he leans over the loom. With the lighting unit in the position shown in Fig. 18, the light comes from the side and confusing shadows will not be in evidence.

If the groups of looms are too far apart to use the spacing of Fig. 18, it is well to keep the rows of units in the work-aisles with the individual units spaced 10 to 16 feet apart in the aisles. Where a unit comes in front of a loom, the spacing can be changed slightly to prevent bad shadows on the work. A suggested grouping of lighting units for long duck or sheeting looms is shown in Fig. 19. An illumination of 6 to 9 foot-candles is recommended. Table IV may be consulted in determining the lamp size.

Bowl-frosted Mazda daylight lamps in RLM standard domes are successfully used in colored cloth weave rooms. As previously mentioned, the blue filter glass bulbs of the daylight lamps ab-

Fig. 15.—No confusing shadows are in evidence in this room, illuminated by standardized lighting. Photograph by courtesy of J. E. Sirrine.



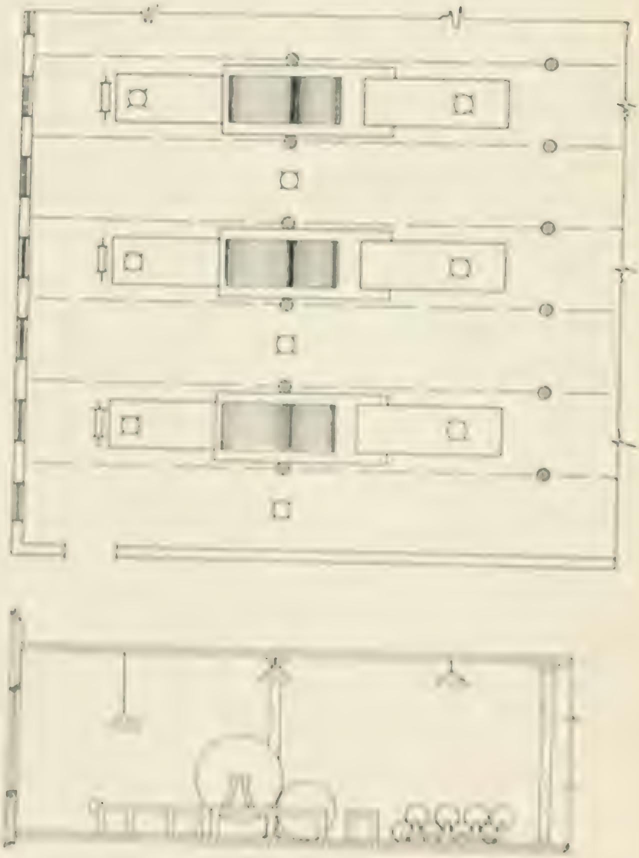


Fig. 16.—A good spacing of the lighting in a warping section.

Fig. 17.—Location of lighting units at the slashers.

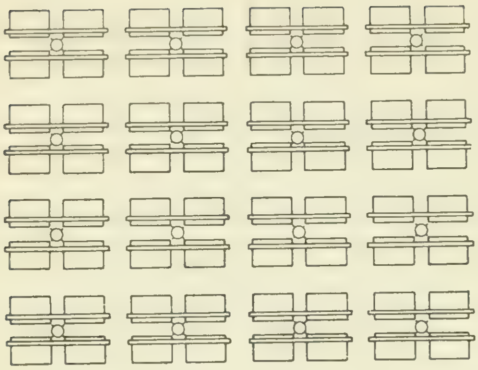


Fig. 18.—One lighting unit per group of four looms. Levels of illumination may be determined from Table IV.

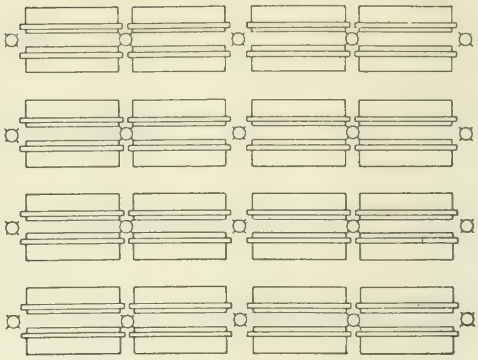


Fig. 19.—Wide cloth weaving may require one lamp and reflector for each two looms.

Fig. 20.—A well lighted cloth room. Two hundred watt diffusing units are spaced to obtain an illumination of 8 foot-candles.

sorb a certain proportion of the light, and daylight lamps of the size next larger than clear lamps must be used to obtain an equal level of illumination on a given spacing.

Jacquard Weaving—The character of the figured materials, towels, etc., woven on Jacquard looms demands better illumination than plain gray or white goods weaving. Inspection of Jacquard woven materials is also more rigid and more exacting. There are very few Jacquard weave rooms of any size where the weavers are able to work even for part of the day by natural light, because practically no daylight can penetrate the rows of high machinery and the maze of warp controls. In addition to the high quality and level of illumination required for this fine grade work, the lighting system must obviate glare and shadows.

In addition to the high light-absorbing machines, many mills have board runways 7 to 8 feet above the floor in each work-aisle to make access easy to the loom work heads. This complicates the lighting problem, because the lighting units must generally be hung below these low runways. The low mounting height requires special consideration of the glare problem, and also introduces the problem of obtaining uniformly distributed illumination. In no case should bare lamps, or reflectors having an insufficient shielding angle, be used. Many bare lamps with reflectors hung low have been used in the past, and the glare endured because it was found difficult to get an even illumination on the work-plane under the runways in any other way. Some thought that when reflectors were used under these conditions, particularly concentrating reflectors, it was necessary to space them too close together. However, there is a simple relation which applies to the distance between reflectors, and the height above the plane of work or machine bed. This relation requires that with the ordinary RLM dome and most other direct lighting reflectors, the spacing distance should not exceed $1\frac{1}{2}$ times the height of the unit above the plane of work. As an example, in a Jacquard weave-room, where it is necessary to mount the reflectors below the board runway so that the height from the loom bed to the reflector is, say, 6 feet, according to the rule, the reflectors should be spaced not more than $1\frac{1}{2}$ times 6, or 9 feet apart to meet the requirements for fairly uniform illumination

on the work. With a 6-foot mounting height above the work a wider spacing than 9 feet would result in uneven and spotty illumination. In those mills where permanent board runways are not found in the work-aisles, the reflectors may be spaced farther apart and mounted higher, as in other parts of the mill. It has been stated by some mill employees that they can reach up under the loom and replace a broken warp control in the dark; however, a type of reflector which has an upward component of light, facilitates this work and saves the employee's time. Prismatic, opal bowl, glass-top porcelain-enameled domes, and the combination glass and steel units satisfactorily light the under side of the work head.

Very little useful light can filter through from the work-aisles to the back-aisles, hence provision for their illumination must be made independent of the lighting in the work-aisles. Whereas an illumination value of 6 to 12 foot-candles is found the most convenient in the work-aisles, a lower level of illumination, such as 4 to 6 foot-candles, will usually be adequate for the back-aisles. An exception to this would obtain in mills which use the portable warp-tying machines at the looms, as these require the same levels recommended for the work-aisles rather than the lower values here recommended for the back-aisles. The back-aisles are not hampered by overhead runways and so the units may be mounted 10 to 14 feet above the floor and spaced as in other parts of the mill. An ideal arrangement is to mount the back-aisle reflectors somewhat higher than the loom work heads so that some light will be furnished at the work heads when needed. Fig. 21 shows an arrangement of Jacquard weave room lighting which has proved satisfactory.

Cloth Room—A general illumination level of 5 to 8 foot-candles is required for ordinary cloth room work such as folding, baling, and boxing. This should be supplemented by a lighting unit over each inspection table so that a total of 8 to 15 foot-candles of well diffused, glare-protected illumination will be provided on the cloth. Dark cloth will require the higher level; gray goods, the lower. Keen, quick vision is required of the inspectors because the cloth is continually moving over the benches, and in order to make it possible to catch and to remedy the flaws with little

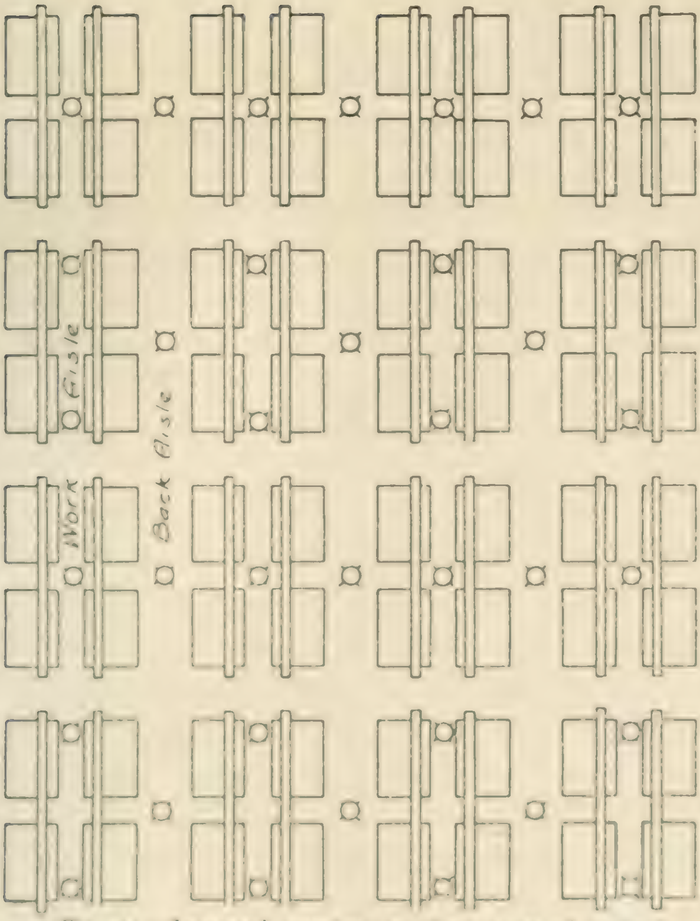


Fig. 21.—Jacquard weaving requires rows of units in both work and back aisles. The close spacing in the work aisles is necessary where the reflectors must be mounted below a low board runway.

Fig. 22.—A convenient arrangement for lighting the drawing-in frames.

delay, the best quality of illumination should be supplied. Since the machines are not located in a uniform arrangement with respect to each other, no standard group lighting arrangements can be shown. Any of the spacing arrangements shown in the paragraph on weaving, will fill the requirements of the cloth room. Table IV shows the levels of illumination obtainable with different spacing arrangements and lamp wattages.

Drawing-in—The drawing-in process requires steady, close application in order that mistakes in drawing the warp ends through their proper harness wires may be avoided. The operators should at all times be seated with their backs to the windows, and should not be required to face any extra bright walls, windows, or lighting units. A good plan is to locate the units behind and approximately above the head of each operator as indicated in Fig. 22.

A good vertical illumination of 6 to 10 foot-candles is needed, such as would be furnished by 100 or 150-watt bowl-enameled lamps and RLM domes in the positions shown.

Machine Shop—Practically every mill has a machine shop and repair department connected with it. The same type of lighting units used in the mill proper can well be used in the machine shop. Bare local lamps on dangling drop cords, miscellaneous tin shades, and reflectors of unknown origin should be replaced by a good general illumination system similar to that advocated for the weaving room. For machine shop work such as lathe, drill press, and bench work, an illumination level of 6 to 12 foot-candles is found to be the best practice.

Lappers and Combing Machines—Where special or very fine yarns are spun from long staple cotton, sliver lappers and combing machines are used. Because of the small number of machines and lack of uniform arrangement, no group lighting recommendations are made. Common practice is to light such machines by general systems providing even illumination throughout, but in which the units are spaced symmetrically without particular regard to the machine arrangement. An illumination level of 6 to 12 foot-candles will give the best results. This means that where the machines are located in the drawing-frame section, a few extra units over these machines to provide added light, will give the desired results.

Quilling—The upper table of the quilling machines should be lighted in the same way as the beam end of a warp machine. The past practice of lighting the bobbins under the table with two bare 25 or 50-watt lamps, is bad. These bare, glaring lamps defeat the very purpose for which they are used; they should in every case be shielded by pear-shaped "half shades" or some other good type of angle reflector fastened under the table that will throw the light upon the bobbins and keep it out of the operators' eyes.

Dyeing—General illumination of from 5 to 7 foot-candles is considered satisfactory for dye houses. This illumination will be provided by a spacing that approximates one lamp watt per square foot of floor area. This spacing means that a 150-watt

bowl-enameled Mazda C lamp in an RLM standard dome on a 12-foot spacing between rows, or a 200-watt lamp on a 14-foot spacing, or on a 12 by 16-foot spacing, approximates one watt per square foot, since there would be a 150-watt lamp for each 150 square feet, or a 200-watt lamp for each 200 square feet on either spacing suggested.

ABSTRACTS

THE INFLUENCE OF TEMPERATURE ON THE TRANSMISSION-FACTOR OF COLORED GLASSES

BY M. LUCKIESH*

It has been shown by Hyde, Cady and Forsythe,[1] Gibson[2] and the writer[3] that the transmission-factors of colored glasses change with temperature. According to the writer's work there was a decrease in transmission-factor in all the cases studied excepting cobalt blue glass. His data on several glasses are presented in the accompanying table. It is seen that the decrease in some cases is very great.

Specimen	Principal coloring element	Color		Relative transmission factors at various temperatures (Centigrade)				
		Cold	Hot	30°	100°	200°	300°	350°
1	Copper	Medium red		100	97	92	87	84
2	Cobalt	Light blue		100	101	104	107	108
3	Cobalt	Deep violet	Deep blue	No appreciable change				
4	Gold	Pink	Violet	100	99	96	94	93
5	Copper	Blue-green	Yellow-green	100	98	94	87	82
6	Manganese	Purple	Blue-violet	100	97	94	91	90
7		Lemon-yellow	Orange	100	94	84	75	71
8		Dull-yellow		100	98	94	91	90
9	Copper	Deep red		100	86	67	50	42
10	Chromium	Yellowish green	Yellow	100	95	84	72	67

Recently some red, amber, green and blue lenses used in a projector unit with 250-watt lamp were studied. The change in transmission-factor when the temperature of the colored glasses increase from room temperature to that attained after the units were normally operated for five minutes are as follows: red

* Director of Applied Science, Nela Research Laboratory, Cleveland, Ohio.

[1] *Astrophys. Jour.*, 42, 1915, p. 302.

[2] *Phys. Rev.* 7, 1916, p. 194.

[3] *Jour. Amer. Cer. Soc.* 2, 1919, p. 743.

glass, decrease fifteen per cent; amber, decrease fifteen per cent; green glass, decrease seven per cent; blue glass, increase about four per cent.

This point should be borne in mind wherever colored glasses are subjected to considerable change in temperature. The spectral transmission characteristics change somewhat with temperature but not enough to be of importance in ordinary lighting and signalling problems.

SOCIETY AFFAIRS

CONVENTION NOTES

The Sixteenth Annual Convention of the Illuminating Engineering Society, held last month at Swampscott, Mass., was most successful both from the viewpoint of attendance and with regard to the information that it has made available to the society's members. More than three hundred members and guests were registered on Thursday night, the fourth day of the convention. The program was particularly attractive, not only because of the subjects included, but also because of the way in which they were grouped. Excellent entertainment was provided, and special lighting effects were a feature of the convention. Of the papers and reports submitted, those on residence and school lighting, a code of luminaire design and cost of daylight were especially interesting.

Dr. Elihu Thomson, who presented the address of welcome, recalled early methods of illumination and traced development down to the present time, saying that tungsten filament cannot be considered the last word in lamp development.

The ideals and characteristics of the society were emphasized by Dr. George S. Crampton, who in his presidential address said that they deserve the unstinted support of all members.

There will appear in the TRANSACTIONS, the various papers and discussions which will give the membership an opportunity to digest the interesting and instructive data pertaining to illuminating engineering which was presented.

On Monday evening a General Assembly with President George S. Crampton was held in the spacious lobby of the New Ocean House and later dancing was held in the ball room.

The papers sessions were well attended by the members and guests and were presided over by various past-presidents of the Society.

On Tuesday evening the hotel and adjacent shore were brilliantly illuminated by searchlights, floodlights playing from the roof of the hotel as well as from the rocks on the shore and from the destroyer in the bay, and a 100,000-cp. incandescent lamp, combined with special float and transparency effects in plain and colored rays. Through the courtesy of the United States Navy Department the destroyer F. Fred Talbot was anchored off shore and illuminated in outline. Ornamental posts illuminated with the emblem of the I. E. S. were a feature of the hotel grounds. Many thousands of motorists and pedestrians attended the display, which was arranged by engineers of the Lynn works of the General Electric Company, with the co-operation of the United States Army.

This spectacular searchlight exhibit was observed in the sky by a great number of persons in Boston and the surrounding towns.

On Wednesday evening a most interesting symposium reviewing the past fifteen years' development in illumination was contributed to by authors of papers at the first I. E. S. convention, namely Messrs. Sharp, Millar, Marks, Bell, Ryan, Hale, Blood, Morrison and Walker.

The convention closed with a banquet on Thursday evening at which General George H. Harries was toastmaster. Addresses were given by a number of notable men such as Dr. Elihu Thomson, Mr. John W. Lieb, Mr. Charles L. Edgar, Dr. Arthur E. Kennelly, Dr. George S. Crampton, and Mr. Ward Harrison.

At the close of this convention Mr. Ward Harrison succeeded Dr. George S. Crampton as the Society's president. Mr. Samuel G. Hibben became the new general secretary upon the retirement after five years of active service, of Mr. Clarence L. Law.

The entertainment features of the Convention were very complete in all details. Luncheons at the Country Club, automobile trips, a bridge tournament, a golf putting contest and a musicale were enjoyed by the ladies. On Wednesday afternoon a golf tournament was held at the Tedesco Country Club for the men, inspection trips through the Motion Picture and Street Lighting Laboratories of the Lynn Works of the G. E. Co. and other points of interest.

The officers and members of the General Convention Committee performed a difficult task in a highly efficient and a very generous manner, and to them are due the thanks of the entire membership for staging the best convention in the history of the Society.

CLEVELAND WINS ATTENDANCE PRIZE

The customary feature of the banquet was observed in the presentation of traveling gavel to the Cleveland Chapter by Mr. D. McFarlan Moore for the best representative attendance during the convention.

Mr. E. W. Commery, Secretary of the Cleveland Chapter, accepted the prize in a fitting manner.

Attendance at the Convention was international in character, members and guests coming from Canada and various parts of the United States.

SECTION ACTIVITIES

PHILADELPHIA

Meeting—October 5, 1922.

A joint meeting was held on Thursday evening, October 5, with the Franklin Institute, before which Dr. Herbert E. Ives of the Research Laboratories of the Western Electric Co. of New York City, presented a paper, "The Primary Standard of Light."

The speaker discussed the various types of candles and lamps first used for standards in the measurement of light, the use of a black body at the melting point of platinum as a standard, and finally the theoretical studies and experimental methods involved.

The attendance at this first meeting of the year was over eighty members and guests.

NEW YORK

Meeting—October 13, 1922.

The first meeting of the New York Section was held in the Engineering Societies Building on October 13, 1922.

The following papers were presented:

"Paint Characteristics and Conditions to be Considered in Effecting Better Illumination," by Mr. C. H. Bryce, Benjamin Moore & Company, Brooklyn, N. Y.

"The Influence of Paint on Interior Illumination," by Mr. R. L. Hallett, National Lead Company, Research Laboratories, Brooklyn, N. Y.

"Paint as an Aid to Illumination from the Machinery Painting Angle," by Mr. L. E. Jamme, Hilo Varnish Company, Brooklyn, N. Y.

"Determination of Reflection Factors of Surfaces," by Mr. W. F. Little, Electrical Testing Laboratories, New York City.

The meeting was well attended, there being over ninety members and guests present.

The annual meeting of the Society was held prior to the Section meeting. Mr. Ward Harrison, President, presided, and the annual report of the retiring General Secretary, Mr. Clarence L. Law, was presented to the Society for approval.

CLEVELAND CHAPTER.

The Cleveland Chapter has recently elected the following officers for the next fiscal year beginning October 1, 1922.

Chairman
Chester L. Dows

Secretary
Eugene W. Commery

Board of Managers
Earl A. Anderson
George A. Hausmann
Phil C. Keller
A. J. Thompson
J. L. Wolf

COUNCIL NOTES

ITEMS OF INTEREST

Upon recommendation of the Board of Examiners the following were elected to membership at the September 28th meeting of the Council at Swampscott:

Two Members.

JOHN L. TUDBURY,
Vice-President,
Salem Gas Light Co.,
247 Essex Street,
Salem, Mass.

BRYANT WHITE,
Electrical Engineer,
Lynchburg Traction & Light Co.,
Lynchburg, Virginia.

Seventeen Associate Members

G. EDWIN BRUMBAUGH,
Architect,
Real Estate Trust Building,
Philadelphia, Pa.

C. MELVIN DOOLITTLE,
Illuminating Engineer,
Westinghouse Lamp Co.,
165 Broadway,
New York, N. Y.

L. D. GIBBS,
Edison Electric Illuminating Co.,
39 Boylston Street,
Boston, Mass.

IRVING T. HOCKADAY,
Salesman,
Southwest General Electric Co.,
1109 City Nat'l Bank Bldg.,
San Antonio, Texas.

ROBERT L. HOSMER,
General Manager,
Eastern Theatre Eq. Co.,
43 Winchester St.,
Boston, Mass.

HERBERT E. A. MCCLENAGHEN,
Optician,
1125 South 20th Street,
Philadelphia, Pa.

RICHARD E. NEWHOUSE,
Secretary-Treasurer,
Electric Supply Co.,
815 East Third Street,
Tulsa, Oklahoma.

C. W. PRINE,
Assistant Professor of Physics,
Carnegie Institute of Technology,
Pittsburgh, Pa.

F. M. REAST,
Publicity Engineer,
Westinghouse Electric & Manufacturing Co.,
East Pittsburgh, Pa.

G. BENJ. RIGHTER,
Schimmel Electric Supply Co.
526 Arch Street,
Philadelphia, Pa.

J. A. SEVILLE,
Electrical Contractor,
209 North 11th Street,
Philadelphia, Pa.

EDWARD ALBERT TUCKER,
Electrical Salesman,
The F. D. Lawrence Electric Co.,
217 W. 4th Street,
Cincinnati, Ohio.

HOLLIS VAUGHN,
Sales Manager,
George H. Wahn Co.
69-71 High Street,
Boston, Mass.

WYNDHAM STOKES WALLACE,
Lamp Salesman,
McKenney & Waterbury Co., Inc.,
181 Franklin Street,
Boston, Mass.

HUGH A. WARNER,
District Illuminating Sales Engineer,
Westinghouse Electric & Mfg. Co.,
1333 Candler Bldg.,
Atlanta, Georgia.

DON M. WELSH,
Assistant Engineer,
Interborough Rapid Transit Co.,
165 Broadway,
New York, N. Y.

L. M WILLIAMS,
New Business Man,
Wisconsin Power, Light and Heat Co.,
Ryson, Wisconsin

The General Secretary reported the following change in membership:

One Associate Member Deceased

FOSTER B. TAYLOR,
New York Edison Co.,
Irving Place and 15th Street,
New York, N. Y.

At the meeting of the Council on October 13, 1922, the following were elected to membership upon recommendation of the Board of Examiners:

One Member.

HENRY B. DATES,
Professor Electrical Engineering,
Case School of Applied Science,
Euclid Avenue at Wade Park,
Cleveland, Ohio.

Eight Associate Members

WENDELL S. BROWN,
Engineer,
F. P. Sheldon & Son,
Hospital Trust Bldg.,
Providence, R. I.

CHARLES LEE CALLENDER,
Manager Sub-Office,
Westinghouse Lamp Co.,
Third and Elm Streets,
Cincinnati, Ohio.

PAUL H. EAMES,
Lamp and Lighting Dept. Salesman,
George H. Wahn Co.,
69-71 High Street,
Boston, Mass.

J. H. GRIFFIN, JR.,
Special Service Dept.,
Edison Electric Illuminating Co. of Boston,
39 Boylston St.,
Boston, Mass.

MUNROE RHODES PEVEAR,
Specialist, Color and Illumination,
Massachusetts Institute of Technology,
71 Brinsner Street,
Boston, Mass.

PHIL C. PFENNING,
Branch Manager,
Westinghouse Lamp Co.,
525 Hanna Block,
Cleveland, Ohio.

RICHARD L. PLATT,
Lighting Service Dept.,
Edison Lamp Works of G. E. Co.,
Harrison, N. J.

HARRY E. ROESE,
Sales Representative,
Westinghouse Lamp Co.,
Union Bank Bldg.,
Pittsburgh, Pa.

The General Secretary reported the following changes in membership:

One Member Deceased

V. C. WYNNE,
Albany, New York,

One Associate Member Deceased

FRANK W. FRUEAUFF,
H. L. Doherty & Co.,
60 Wall Street,
New York, N. Y.

CONFIRMATION OF APPOINTMENTS

The appointments of the following chairmen and committee members were confirmed:

Council Executive Committee
Ward Harrison, Chairman
Samuel G. Hibben
Walton Forstall
Clarence L. Law
Louis B. Marks

Committee on Finance
Adolph Hertz, Chairman
Walton Forstall
D. McFarlan Moore

Committee on Papers
J. L. Stair, Chairman
A. L. Powell, Vice-Chairman
E. A. Anderson
Louis Bell
Geo. G. Cousins
H. H. Higbie
Howard Lyon
Norman D. Macdonald
F. H. Murphy
J. J. Ryan

Committee on Editing and Publication
Norman D. Macdonald, Chairman
Allen M. Perry
Ralph C. Rodgers

General Board of Examiners
Norman Macbeth, Chairman
Clarence L. Law
L. J. Lewinson

Committee on Lighting Legislation
L. B. Marks, Chairman
W. F. Little, Secretary
Louis Bell
W. T. Blackwell
F. C. Caldwell
C. E. Clewell
Geo. S. Crampton
H. B. Dates
S. G. Hibben
J. A. Hoeveler
Clarence L. Law
M. G. Lloyd
M. Luckiesh
R. H. Maurer
A. S. McAllister
W. J. Serrill
R. E. Simpson
G. H. Stickney

Committee on Membership
G. Bertram Regar, Chairman
A. L. Arenberg
C. A. Atherton
W. T. Blackwell
F. W. Bliss
R. I. Brown
Geo. G. Cousins
Terrell Croft
J. Daniels
E. Y. Davidson, Jr.
Robert B. Ely
H. W. Fuller
H. E. Hobson
J. A. Hoeveler
Merritt C. Huse
C. C. Munroe
F. H. Murphy
E. W. Spitz
Clare N. Stannard
O. R. Toman
L. J. Wilhoite
L. A. S. Wood

Committee on Motor Vehicle Lighting

C. H. Sharp, Chairman

Committee on Nomenclature and Standards

E. C. Crittenden, Chairman
Howard Lyon, Secretary
Louis Bell
G. A. Hoadley
E. P. Hyde
A. E. Kennelly
C. O. Mailloux
A. S. McAllister
C. H. Sharp
G. H. Stickney

Committee on Progress

F. E. Cady, Chairman
Geo. S. Crampton
W. E. Saunders

Committee on Research

E. P. Hyde, Chairman
Louis Bell
W. T. Bovie*
Alex. Duane
Knight Dunlap
E. N. Harvey*
M. Luckiesh
C. H. Sharp
C. A. Skinner*
L. T. Troland
F. N. Verhoeff*

Committee on Sky Brightness

H. H. Kimball, Chairman
E. C. Crittenden
E. H. Hobbie
Bassett Jones
W. F. Little
M. Luckiesh
L. B. Marks
I. G. Priest*

Committee to Co-operate with Fixture Manufacturers

M. Luckiesh, Chairman
E. W. Commery, Secretary
S. G. Hibben
J. W. Gosling*
R. H. Maurer
A. L. Powell
Samuel Snyder

Committee on New Sections and Chapters

D. McFarlan Moore, Chairman

Committee to Prepare a Bulletin on Residence Lighting by Gas

Howard Lyon
R. H. Maurer

Committee to Prepare a Bulletin on Residence Lighting by Electricity

Samuel G. Hibben, Chairman
Geo. Ainsworth
F. E. Cady
O. H. Caldwell
W. J. Drisko
R. B. Ely
Gertrude R. Ferree*
R. S. Hale
F. Y. Joannes*
Clarence L. Law
M. Luckiesh
W. R. M'Coy
Herman Plaut
A. L. Powell
F. B. Rae, Jr.*
R. C. Rodgers
J. W. Smith*
J. L. Stair
E. D. Tillson
D. H. Tuck

Mr. W. H. Rolinson has been appointed manager of the interior lighting section of the merchandising department of the Westinghouse Electric and Manufacturing Company with headquarters at South Bend, Indiana. He has recently been assistant to the sales manager of the Westinghouse Lamp Company of New York City.

* Not members of the Society but co-operating in the work of these committees.

NEWS ITEMS

DOHERTY MEDAL WON BY WILLIAM H. EVANS

The honor of winning one of the most important awards made yearly by the National Electric Light Association has come to the Philadelphia Electric Company for the third time in twelve years.

Each year since 1911 the Doherty Gold Medal is awarded to the author of the best paper read before a branch meeting of section of the national body, the award being made by a committee of three. William H. Evans, of the Philadelphia Electric Company, is this year's winner with a paper, "Much and Good Business, Plus Advertising, Means More and Better Business," which is printed in *The Central Station* for October, 1922.

Mr. Evans is a member of the I. E. S. and his paper is the first advertising paper to win the Doherty Medal.

A. E. S. C. HANDLING 106 PROJECTS

The growing interest in standardization on the part of almost every American industry is emphasized by the quarterly report of the activities of the American Engineering Standards Committee issued from the headquarters of the Committee at 29 West 39th Street, New York City.

Of the projects which have official status before the A. E. S. C., twenty are concerned with mechanical engineering; seventeen are civil engineering projects; fifteen are electrical; three are automotive; ten are concerned with transportation; ten with ferrous metals; eleven with chemical; five with non-ferrous metals; four with mining; two with textiles; one with shipbuilding; and eight projects are of general interest.

Twenty-four standards or safety codes have been approved and thirty-six are up for approval. The remaining forty-six projects represent codes and standards which are either in the process of formulation, or which are now being considered by committees of representatives, designated by the various bodies, industrial, technical and governmental, interested in each particular subject. In this way, more than two hundred such bodies are officially participating in the work of the A. E. S. C. through their accredited representatives.

A regular interchange of information as to the status of work under way is maintained by the American Engineering Standards Committee with the national standardizing bodies of Austria, Belgium, Canada, Czech-Slovakia, France, Germany, Great Britain, Holland, Italy, Japan, Norway, Sweden and Switzerland. This information is issued in the form of quarterly reports and includes a statement of the status of each project on which work is actively under way.

The A. E. S. C. has adopted two of the I. E. S. projects as "American Standard," namely "The Code of Lighting Factories, Mills and Other Work Places," and "Illuminating Engineering Nomenclature and Photometric Standards." A third project is under consideration for adoption as "Tentative American Standard"; namely "Laboratory Tests for the Approval of Electric Headlighting Devices for Motor Vehicles."

ILLUMINATION INDEX

Prepared by the Committee on Progress.

An index of references to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

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TRANSACTIONS
OF THE ILLUMINATING ENGINEERING SOCIETY

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Co-operation of the I. E. S. and the A. E. S. C.

NOT THE LEAST important of the numerous activities of the Illuminating Engineering Society are those carried out in official co-operation with other organizations under the Rules of Procedure of the American Engineering Standards Committee.

With these activities the members of the Society have been kept posted by notices published from time to time in the TRANSACTIONS, but it seems well at this time to summarize these activities and show their present status and the trend of progress.

In June, 1920, the I. E. S. was designated as sponsor for the Industrial Lighting Code, and for the purpose of revising its code for the Lighting of Factories, Mills and Other Work Places organized a sectional committee containing official representatives of fourteen organizations, including the I. E. S. The code approved by this sectional committee was officially approved as American Standard by the American Engineering Standards Committee in December, 1921.

In March, 1921, the I. E. S. submitted its Automobile Headlighting Specifications for approval by the American Engineering Standards Committee as tentative American Standard. On account of certain changes which the I. E. S. desired to introduce into the specifications, in June, 1921, the A. E. S. C. was requested to hold the application in abeyance, and the Headlighting Specifications were resubmitted in revised form in February, 1922.

In November, 1922, in accordance with the request of the I. E. S., the A. E. S. C. gave its formal approval to the I. E. S. specifications under the specific title of Laboratory Tests for the Approval of Electric Headlighting Devices. It also invited the I. E. S. and the Society of Automotive Engineers to act as joint sponsors for the preparation of specifications relating to all types of automobile headlighting devices. Both the I. E. S. and the S. A. E. have formally accepted the invitation of the A. E. S. C. and the organization of a thoroughly representative sectional committee under their joint sponsorships will shortly be undertaken.

In March, 1922, the I. E. S. added its request to that of the International Traffic Officers Association that the A. E. S. C. call a conference of interested organizations to determine the advisability of standardizing colors of signal lights along highways and on vehicles using the highways. On May 23, 1922, there was held in New York a thoroughly representative conference on Colors for Traffic Signals, as a result of which there has recently been organized under the joint sponsorship of the American Association of State Highway Officials, the Bureau of Standards and the National Safety Council a sectional committee on which the I. E. S. is represented by the Chairman of the Committee on Motor Vehicle Lighting.

In March, 1922, the I. E. S. submitted the "Rules" prepared by its committee on Nomenclature and Standards to the American Engineering Standards Committee for approval as American Standard. At the suggestion of the I. E. S., six of the "Rules" were modified in order to conform in wording with the English translation of six of the definitions of the 1921 report of the International Commission on Illumination, and in July, 1922, the "Rules" were approved by the A. E. S. C. as American Standard under the title of Illuminating Engineering Nomenclature and Photometric Standards. The A. E. S. C. also designated the

I. E. S. as sponsor for this subject, and a thoroughly representative sectional committee is now being organized under the sponsorship of the I. E. S. to take care of revisions in the present "Rules" of the I. E. S. Committee on Nomenclature and Standards.

In recognition of the interest of illuminating engineers in building exits the I. E. S. was requested in September, 1922, to designate a representative to serve on the Sectional Committee on Safety Code for Building Exits which has been organized under the sponsorship of the National Fire Protection Association.

To those unfamiliar with the exact significance of the co-operation with other national organizations under the Rules of Procedure of the American Engineering Standards Committee it might seem that the I. E. S. gains little and loses much by such co-operation. Experience has shown that in every case the gain has greatly exceeded the loss; in fact the gain has proved to be real and the loss fictitious. In no respect does the I. E. S. lose its identity through co-operation; it gains in prestige and receives a substantial recognition for the most excellent work of its technical committees. Its own activities have not been restricted in any way; on the contrary its influence has been felt by numerous national organizations who have gladly assisted the I. E. S. in extending the sphere of its activities. Both it and the other co-operating organizations have benefited not only from the interchange of information and but also by reason of the spirit of mutual helpfulness which has been an outstanding feature of the co-operation.

A. S. McAllister.

REFLECTIONS

Useless Motor Car Rear Lamps Cast Out in Massachusetts

WHILE New York State motor officials are still wrestling with the automobile headlight situation, Massachusetts seems to have solved that problem in a fairly satisfactory manner and is now tackling very vigorously the tail or rear lights. A new tail-lamp law goes into effect on Jan. 1 in that State and the changes which are rendered imperatively necessary by that law have disturbed to some extent manufacturers as well as Massachusetts motor car dealers and owners.

In view of the widespread interest in proper automobile lighting, this attitude on the part of Massachusetts in tail-lamp legislation is of considerable importance, because it undoubtedly will pave the way for some necessary changes in all of the Eastern States and ultimately, no doubt, throughout the country. To use a sporting phrase, this progressive New England State seems to have got the jump in adopting tail-lamp regulations on the Illuminating Engineering Society which has had a special committee working on that subject with the object of arriving at more exact specifications for proper tail lights than exist at the present time.

This society, it may be said, working with the Standards Committee of the Society of Automotive Engineers, adopted specifications for automobile headlights about five years ago, and these have been adopted by the ten States comprising the Interstate Conference of Motor Vehicle Commissioners, being the six New England States with New York, Pennsylvania, New Jersey and Maryland. They are also in use in other States. New York, notwithstanding its laxness in this respect, as admitted at a recent meeting in this City by Bert Lord, Director of the State Motor Vehicle Bureau, is now coming up to the standard of some of these States, and in its revision of lenses has already cast out sixty-seven of those formerly approved, and several others will probably meet the same fate before the end of the year.

In speaking of the tentative specifications announced by the Massachusetts Registrar of Motor Vehicles, Frank A. Goodwin, Dr. Clayton H. Sharp, Chairman of the Illuminating Engineering Society's Committee on Automobile Lighting, said last week, just before sailing for Europe to study lighting conditions abroad,

that while definite specifications had not been adopted by the committee, the practical application of the Massachusetts regulations would undoubtedly form a fundamental basis upon which to work, and certain details, of whose excellence he was in doubt, could be satisfactorily adjusted as the result of experience.

In formulating its new tail-lamp regulations Massachusetts has been fortunate in having on its motor advisory staff Alfred W. Devine, who is Chairman of the subcommittee of members of the Motor Vehicle Lighting Committee of the Illuminating Engineering Society and the Lighting Division of the Society of Automotive Engineers. That committee has been doing considerable experimental work on rear automobile lights, but has not yet made its final report.

Without going into too many details, it may suffice to say that the requirements drawn up by Mr. Devine with Registrar Goodwin's approval require a bulb to illuminate the number plate of not less than two candlepower, that the slot through which the light shines shall be covered with glass, that it shall be so constructed that the lamp and bracket to which the number plate is affixed shall be one device, and that the lamp shall be above the centre of the plate. The law also requires that the white rear light shall be so placed as to make the plate number visible at a distance of 60 feet from the rear of the car. The New York requirement, and that of most States, is 50 feet.

For oil or acetylene lamps, the Massachusetts requirements specify a four candlepower light and these lamps may be placed at the left end of the plate.

The Massachusetts tail-lamp law has been discussed by the Legislative Committee of the National Automobile Chamber of Commerce, and one of the members stated that the original requirement of making the lamp and bracket an integral part of the number plate had been modified to the extent that the lamp should be solidly affixed to the plate.

Conformity with this law will make it necessary for the manufacturers selling cars in Massachusetts, and that includes all of the makers of standard cars, to manufacture a new style of rear lamp. The committee of the National Automobile Chamber of Commerce has, very wisely, suggested a voluntary acceptance of the law. The result will virtually be that all cars will, in the near future, be fitted with rear lights conformable to the Massachusetts law, thereby automatically enacting better regulations in all States whether done by legislative act or not. Indeed, it is stated that all of the other nine States in the interstate conference for uniformity in motor laws will soon adopt the Massachusetts policy, perhaps with minor improvements. For owners of old

cars in Massachusetts Mr. Devine is quoted as saying that the expense of providing proper rear lamps will not exceed \$3, and some of the tail lamps submitted and approved can be made to sell for \$1.50 to \$2, according to the information given to Mr. Devine.

An investigation of tail-light efficiency was lately made by Registrar Goodwin in several cities, and of 205 cars stopped and whose rear lights were tested only one was found that conformed to the new law. In 176 cases the lamp was improperly located, in 124 cases the lamp had defective celluloid or no covering of the lamp slot, and in 97 cases the slot was too small. Practically every careful observer of automobiles on the city streets at night will recognize that the rear lighting, in so far as it illuminates the plate number, is not what the law requires it to be. At a distance of even 25 feet it would often be difficult to see the entire number. Two or three figures might stand out with tolerable clearness. The law does not state how the lamp shall be affixed, and, so far as known, Massachusetts is the first State to establish a definite situation where the light may do the most good.

Another detrimental feature in regard to the illumination of number plates is due to their grimy and dusty condition. This may be due to carelessness, but it is quite possible that some owners do not object to a little obscurity caused by the dust and grime of the road. In Pennsylvania, last Summer, the police in two or three towns stopped a number of motorists and obliged them to clean the number plates on the spot. The law says that the light shall illuminate the plates, and if the light is all right the next step will probably be to insist with more rigor that the numbers are clear enough to be illuminated.

The list of approved rear lamps for Massachusetts, it is stated, will be made by Nov. 15, so that manufacturers can make proper provision for equipment on cars sent out after the first of the year. *New York Times*, November 5, 1922.

Toronto Approaches the Ideal in Street Lighting

TORONTO is naturally adapted to parks and lakeshore drives, but not until the last six months did it have a boulevard worthy of any particular note.

Some years ago a scheme was worked out for the construction of a boulevard along the entire waterfront, reclaming the land along the lake shore where necessary. Three or four miles of this highway in the Sunnyside district at the west end of the city are now open to traffic.

In the summer of 1920, the question of lighting the boulevard came to the front. The matter was one which warranted considerable thought, for although only a few miles of the work had been completed at that time, a lighting system was to be decided upon which could be standardized for the whole length of the waterfront.

After considerable time had been spent on the display of sample units by various manufacturers, it was decided, from an ornamental standpoint and from a maintenance point of view, to adopt an octagonal cast bronze lantern, the unit to be equipped with opalized stippled glass panels on the sides and top, and each unit to be complete with an 8½-inch Holophane dome reflector, with a porcelain enameled top reflector, constituting the reflector holder, to obtain the maximum candlepower on the road surface. These lanterns were to be mounted on ornamental poles, the light center to be approximately 15 feet from the ground, the units being placed opposite and 100 feet apart. The ornamental bronze lanterns and cast iron capitals were supplied by the Canadian General Electric Company, Ltd., the poles being supplied by the Union Metal Co., of Canton, Ohio.

Another point worthy of note is the fact that this is the first series system installed in the city of Toronto. The remainder of the street lighting, which consists of some 60,000 lights, is fed from multiple circuits; but after making comparisons on lamp life, illumination, costs, and flexibility between the series and multiple systems, the engineers of the Toronto Hydro-Electric System recommended that the series system should be used on this new boulevard lighting scheme. This was sanctioned, and the system laid out with a series I.L. 1,000 c-p. transformer buried in the ground at the side of each standard, stepping the current up from 6.6 to 20 amperes. On the side streets running off the boulevard, there were erected on poles 20-kilowatt constant current transformers, to feed the system. The ultimate intention is to dig waterproof pits and install these transformers under ground. At the present time there is only a 600 c-p., 20 ampere lamp used in each unit, although the capacity of the I.L. transformer is 1,000 c-p. A point of interest in connection with this installation is that the entire equipment had to be supplied for a frequency of 25 cycles, as practically the whole of Toronto is supplied with 25-cycle power from Niagara Falls.

The system has now been in operation a few months and has met with the entire approval of all three bodies which were instrumental in deciding on the lighting scheme. It is considered one of the most efficient incandescent street lighting systems in

Canada. It is also proving a wonderful advertisement and has created a desire among the citizens of Toronto for better lighting in the remainder of the city. The system is being inspected continually by neighboring engineers and when any section of Toronto or a neighboring city is considering street lighting it is the habit to use the Sunnyside Boulevard as an example of ideal illumination.—*The Digest,* July-August, 1922.

PAPERS

LIGHTING FOR PUBLIC EATING PLACES*

BY J. L. STAIR**

INTRODUCTION

SYNOPSIS: Suggestions of public eating houses are found in the records of mythology. The development, however, of these institutions, so far as the human race is concerned, came after travelers began to extend their journeys throughout the land and [illegible] places of rest and refreshment.

The inns and taverns, especially those in England and America in Colonial times, present an interesting field for the study of national manners and customs. The flickering light from oil lamps and tallow candles provided the means of illumination in these early hostelries.

The coffee house followed the establishment of inns and taverns, and the restaurant, a comparatively modern innovation, had its beginning in France about the year 177[illegible].

Our present day eating places include a varied assortment which might be classified into four general groups as far as the requirements of lighting and artistic treatment are concerned: First—Cheap lunch rooms which offer only a simple service. Second—Those in which some artistic features are to be combined with the utilitarian lighting. Third—Those in which artistic treatment is of greatest importance; and Fourth—Those in which special forms of illumination are required.

The general requirements that are to be carefully considered in the illumination of any type of public eating place would include the following: (1) The provision of the proper intensity of illumination. (2) The avoidance of all glare effects. (3) Consideration for color harmony. (4) Care in the design of the luminaire. (5) Provision for flexibility of the lighting system because of the variety of functions that are often included in the life of this type of establishment.

The historical background of the picture against which we may view the modern public eating places presents an intensely interesting perspective. The details back at the origin and many of those in the middle distance, are so greatly obscured that many of the steps in the transition from the old time hospitality of friends to the present day commercial hospitality, must necessarily be supplied by the imagination.

If we are to take the word of the mythological writers, the first dining club was formed in Elysium, then transferred to Mt.

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**Chief Engineer, National X-Ray Reflector Co., Chicago, Ill.

Olympus in the center of a vast forest of chestnut trees which Ceres had caused to spring up and bear in abundance. After a while, as a reward for their great piety, the Grecian men were granted by the Gods, sufficient land to build a sacred city and a charter for the club. Needless to say, many imitations were made of the original club and its first branch, but to inquire into their inception and purposes, would require more time than we have at our disposal.

According to tradition, the Spartans instituted public meals in order to correct extravagance. All citizens were required to eat at the common table, not even the kings were excused. It is stated that the refectories consisted of spacious halls in which were tables of rough boards placed upon trestles, and the seats were plain wooden benches. These halls were styled "Philition" by the Spartans.

For many many years the Greeks in their primitive simplicity sat at tables to eat, but after their European Conquest, they became more luxurious and adopted the Persian custom of reclining on couches. Later on the Romans in imitation of the Greeks, likewise reclined on couches while eating. It was decreed in those early days, that the number of persons at the dining table should not exceed twelve. The Romans usually entertained nine guests, three on each of their three couches. Hence the name "Triclinium" was given to the dining room.

It seems that neither in Athens nor in Rome much attention was given to the decoration, ventilation or illumination of the refectories except in some of the great halls of the wealthy Epicureans. One writer states that the ample dining halls of the renowned Lucullus were said to be airy, richly decorated and brilliantly lighted.

INNS AND TAVERNS

The establishment of public inns came along with the widening greatness of the Roman World Empire. Posts of entertainment were established along the magnificent roads by which the empire was bound together. The more the traveller extended his journey, the less likely he would be to find houses to which he was bound by friendly ties of genuine hospitality, and on the other hand, those that remained at home would find the constantly increasing duties of voluntary host growing to be a

burden. No doubt the householder was greatly relieved to see the establishment of public inns and probably had a part in their development when he sought relief by charging his guests a nominal sum to defray their expenses.

It was about this time that the distinction between pure hospitality and commercial hospitality began. We do not know just when, but there appeared centuries ago, an insc:iption over a door in Pompeii bearing the following words: "Hospitium hic locatur"—Hospitality for hire.

In England the inns began with the Roman conquest. It is evident that the Britons whom Julius Cæsar conquered, required no accomodations of this character, whereas the colonizing Romans were used to inns and soon covered Briton with a system of roads and hostelries for the accomodation of both soldiers and civilians. These Roman inns were apparently swept away by the Anglo-Saxon invaders, and for two or three centuries, no places of rest or refreshment for travellers were to be found until monasteries had been established throughout the land. As travelling became more general, lodging houses were subsidized and inns were again established.

Fig. 1.—Chaucer's Pilgrims seated around a table at the "Tabard," Southwark

One of the earliest English hosts of whom we have any knowledge, was Harry Bailey, landlord of the genial hostelry, the

"Tabard" at Southwark. Chaucer's immortal poem, "The Canterbury Tales" states that a group of the pilgrims assembled at this famous inn. The illustration in Figure 1 shows the artist's conception of them seated around the table at the Tabard.

The early inns provided little comfort and less privacy. By the close of the 16th Century, however, the character of the English inn was greatly improved. The inn and tavern life of old England, as well as that of America in Colonial times presented a large field for study of national manners and customs and played an important part in the history of the country. These were not merely places for the sojourn of travellers, but became the meeting places of poets, wits and politicians from the time of Shakesphere to that of Addison and Johnson, and the recognized center for social intercourse. The more homelike the inn, the greater the assurance of its patronage, popularity and prosperity. The 16th, 17th and 18th Centuries, especially in England, show a remarkable development of these public establishments.

A long list could be given of the famous old taverns of England and America. Typical of those of England, is the "Cheshire Cheese," the chief glory of which was the old fashioned eating room with rude tables, seats around the walls and sawdust sprinkled floor. This quaint place was made famous by Dr. Johnson. The following verses taken from a ballad written by John Davidson, hint as to the type of lighting that was employed:

"All Hail,
Great souls! They met on nights like these,
'Til morning made the candles pale,
And revellers left the Cheshire Cheese."

The institution of inns and taverns in America followed immediately upon the settlements made by the Pilgrims and they were licensed as fast as villages grew up. Many interesting accounts have been recorded of life in the inns and in some, descriptions have been made of the lighting effects, especially for stated occasions. One writer in 1778, in describing a celebration at "Kings Head Tavern" in the New York Colony, remarked on the grand and elegant lighting effects, stating that the tavern was illuminated with upwards of two hundred wax lights. A descrip-

tion was also given of transparencies, and mention of the fact that verses over the tavern door which were proper for the occasion were well illuminated.

Another writer states that grand preparations were made for a supper ball in honor of the peace of 1815 at Washington Hall, and that the garlands extending from the pillars were attached to a central canopy beneath which was a golden sun made to revolve rapidly by machines above the ceiling so as to diffuse the reflected radiance of eight hundred lights.

A lieutenant in writing to a friend in England under date of October 17, 1881, refers thus to Loosleys' "Kings Head Tavern"—"The effects would be offered at public auction for the benefit of the creditors of Chas. Loosley. Among the articles mentioned which indicates that the house was rather nicely furnished were . . . . several hundred transparancies, and tin lamps fit for illuminations."

Still another narrative includes the following paragraph—"Gathered together to celebrate one of the anniversaries of the festive season, the flickering light from oil lamps and tallow candles reflected from the white washed walls of Madam Wessles' Assembly Room, shown on as happy and gay hearted a gathering as is found in the magnificent and brilliantly lighted halls of our present grand cities."

We have nothing existing to-day that in any way resembles the old tavern of the first class in Colonial times, since it was a place of political discussion, for social clubs and meetings of all kinds. Before any news papers appeared, the tavern was a very important institution in the community. It was the medium of all news, and exercised an influence second only to that of the church. As a prominent feature of society and manners, the tavern has had its day. As one writer stated, "The simple truth is that in moving on, the world has left this venerable institution standing in the 18th century."

THE COFFEE HOUSE

After our forefathers had perfected the inns and taverns, they set to work developing a new species of public house known as "the coffee house" and it is this establishment that appears to have been responsible for the development of the club. During the latter part of the 17th century, the use of coffee as a beverage

was introduced in New England and on the continent. The first coffee houses in Paris were opened in 1672. Previous to this time they were established in London, since we find that in 1663 they were placed on the footing of the tavern and were required to be licensed. The coffee house, however, along with the inn and tavern, exists only as a picturesque memory.

The advent of the railroad and great increase in travel, as well as growth of cities, created a decided change in the taverns. They soon became to be called "hotels." These same influences are responsible for the development of the restaurant, cafe and other types of eating houses.

THE RESTAURANT

The restaurant is a modern innovation, and is not considered a direct development of the inn and tavern. France is primarily the home of the restaurant. No other country could have supplied either the utilitarian basis for its existance or the fastidious clientele. The real rise of the restaurant proper dates back to the close of the 18th century and owes its principal growth to the fact that a great many families with their estates broken up, found it convenient to patronize the public eating house. The first restaurant was founded in Paris about 1776 by a hotel keeper by the name of Boulanger, where the customers were served with boullion on marble tables, as in our cafes. The idea became popular because it was novel and the prices were high which gave the establishment a distinction and kind of polish. He was so successful with his unheard of enterprise that it not only sprang into immediate popularity, but the idea spread to the utmost parts of the globe. The Parisian restaurant acquired cosmopolitan fame and it is only of recent years that the restaurants of even the foremost American cities, have rivalled them.

PRESENT DAY EATING PLACES

Our present day offers us a varied assortment of eating places that almost defies classification. In early New England there were taverns for the gentry and taverns for the mechanics, to compare with our types, catering to important business people, serious folk, pleasure seekers, rich strangers, office and shop employees, workmen, etc.

Lunch rooms, cafeterias, automats, cafes, summer gardens, commercial restaurants, hotel dining rooms, lunch clubs, industrial restaurants, club dining rooms, tea rooms, coffee shops, ad infinitum, provide a truly fertile field for the "gastronomic adventurer."

CLASSIFICATION

An arbitrary grouping of public eating places can be made based upon their requirements for lighting and artistic treatment.

Group "A" Includes the cheap lunch room that offers a very simple service, and many of the industrial dining rooms. These present practically no artistic considerations. The lighting is therefore of a purely utilitarian nature.

Group "B" This group comprises those establishments in which a general illumination is usually satisfactory and in which the artistic must be considered, especially in the design and finish of lighting units. As for instance, commercial restaurant, cafeteria and better class of lunch room.

Group "C" This class requires a more purely artistic treatment and necessitates the creating of an atmosphere more homelike than the classes mentioned above. Color plays an important part, and artistic touches of light and shade are desirable. Under this class comes the dining rooms of hotels and clubs, as well as high class cafes and tea rooms.

Group "D" There is still another class that might be considered as special from the illumination standpoint and includes those establishments which provide entertainment such as dancing, skating and cabaret, and which require some unusual, if not spectacular, lighting arrangements.

The miscellaneous departments such as kitchens, lobbies and rest rooms are common in a greater or less degree, to all public eating places, and must be considered apart from the main dining hall or space.

GENERAL LIGHTING REQUIREMENTS

One of the errors that is often made in planning the lighting of the class of interior under consideration, is to assume that

the fundamental conditions are much the same as those for a store, office or many other interiors frequented by the public. For this reason, we often find them illuminated with the same types of units installed in a manner similar to those in mercantile establishments. For the cheaper class of lunch rooms and restaurants, this arrangement is no doubt satisfactory, but the requirements of the higher class places are quite different. Visibility is not the chief consideration.

For many people, the public eating place must serve as a substitute for the home, with the manager as host, and hence we might consider that the ideal would be approached by following the three essential elements which stimulate the atmosphere of coziness in the dining room of the home.

1. Concentration of light upon the table to accentuate the setting of linen, silverware and glassware, with the proper shading so that the eyes of the diner never meet the direct source of light.
2. Providing of a suitable intensity of general illumination throughout the room.
3. Supplying of a tinted light to fall upon the faces of those seated about the table.

These three essentials are necessarily difficult to apply in large establishments, but by careful designing can be attained to a great degree in clubs, tea rooms and cafes, to give even in these public places, a sense of privacy and intimacy.

There seems to be, especially in commercial restaurants, a tendency to over-lighting. The public eating place should, of course, reflect the atmosphere of the society that it entertains. If the patrons go to see and be seen, a general bright illumination is, of course, most proper.

In any case, strong contrasts should be avoided. For instance, Figure 2 shows a cafeteria well equipped for the serving of its patrons. Careful attention has been given to the table arrangements and to other details essential to successful operation, yet the lighting system can be described by one word, "glare" which is accentuated by mirrored walls and columns and a ceiling finish that reflects the radiance of bare lamps in the ceiling pieces and wall brackets.

Surely, a condition of this kind cannot be entirely comfortable for the patron, and is not in keeping with the general appointments of the room. Hundreds of public eating places having similar or worse conditions, can be corrected at comparatively small expense. The simple expedient of shields and shades around the lamps and fixtures would enclose bare lamps and be a great improvement. No doubt some day, the quality of exactitude will be exercised by the patrons in the matter of glaring lighting as it now is regarding prompt service, clean linen and silverware and well cooked food.

Attractive color combinations are essential, and since the dining room is a place of stimulation, a warm light is usually demanded. Depressing tones should therefore be avoided. A progressive restaurant keeper recently said that the room should not be shiny and white. It smacks too much of the hospital, and is trying both on the eye and nerves. The filtering of light through silk, parchment and colored glass, with tints such as amber and rose always give a touch of warmth to the illumination.

The average layman is not usually attracted by details, but he is impressed by the general harmonious effect of the interior. Hence the lighting fixtures for better classes of eating places, especially those to be found in hotels and clubs, must be designed to harmonize with the interior furnishings and decorations of the room, as well as to produce proper lighting effects. Fixtures of this character cannot be purchased from stock, because stocks cannot be prepared to meet the various demand without unwarranted cost and sacrifice of many of the details of individualism. Each interior has its own peculiar architectural and decorative details which call for specialized designs.

As an illustration of what should not be done in the design of the lighting fixture, Figure 3 is presented. It is evident that careful attention has been given to the furnishing of this restaurant, but a lighting fixture has been installed that is very inharmonious, consisting chiefly of a bowl of glass surrounded by a series of large ball frosted lamps with one projecting without any apparent reason, from the bottom of the ornamental bowl.

In many cases, the design of the fixture is too elaborate. It does not convey the general ideas of comfort, quiet and simplicity which are essential if the homelike appearance of the interior

is to be maintained. However, the fixtures in the banquet hall and places of a similar character can tend in their design, more towards giving the impression of massiveness and splendor.

There are many public eating places in which a flexible lighting system is necessary because of the variety of functions that are often included in the life of the particular establishment. Means should be provided so that the general illumination of moderate or fairly strong intensity can be produced for such occasions as banquets, and general gatherings. While subdued values of intensity can be obtained for more usual occasions.

Dining rooms, especially in hotels, often serve for the purpose of an assembly room and are used for banquets, conventions and noon day luncheons. On such occasions, it is usually desirable to have a flood of light. Many of these rooms are equipped with wall brackets in addition to the fixtures for general illumination, and almost without exception, when a speaker is addressing the assembly, glaring bracket lights directly behind the speaker's platform are allowed to shine into the eyes of persons endeavoring to concentrate their attention on the remarks of the talker.

Lighting conditions of this kind are especially objectionable when the platform is situated at one end of the room and it is almost impossible to seat oneself so that the glaring lamps will be out of the range or vision when looking at the speaker. To sit an hour through facing these lamps is a very uncomfortable experience.

In the planning of banquet rooms, this very important condition should be kept in mind and if bracket lights are desired to avoid monotony they should be well shaded and used principally for the touch of color that they might add in the artistic scheme.

EXAMPLES OF MODERN LIGHTING PRACTICE

The examples of modern lighting in public eating places that are to be described and illustrated in the following paragraphs have been carefully selected to conform to the classification that was given above.

The Group "A" of the classification included those interiors requiring a purely utilitarian type of lighting. For instance, Figure 4 illustrates an industrial lunch room typical of many of the larger manufacturing plants. These dining halls are the result of thoughtful planning over a period of years, and in the ma-

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Fig. 2.—Cafeteria which illustrates the distressing effect of glare from the lighting system.

Fig. 1.—Dining room illustrating lack of thought in design of the lighting fixture.

Fig. 4.—Typical industrial cafeteria in which indirect lighting system is employed.

Fig. 5.—Interior typical of the commercial restaurant. The low ceilinged room, in which the luminous type of indirect fixture is suspended on short chains, gives excellent lighting results.

jority of cases are operated on the cafeteria plan. In one large plant, five hundred to seven hundred people are served in the short space of 30 minutes. Good lighting is therefore very essential in order that service be speedy and orderly. It is evident from the illustration that very few artistic considerations are encountered in an interior of this kind, the chief problem being that of supplying a well diffused general lighting.

To illustrate the eating places that come under the second or "B" grouping of the classification, Figure 5 shows a typical commercial lunch room. It will be noted that the luminous type fixture is employed and the arrangement is such as to give a general lighting effect. More consideration is given here to the artistic character of the lighting unit than in the example illustrated in Figure 4.

Not more than ten years ago, cafeterias in the cities were represented by few second floor and basement locations, generally known as lunch clubs, and patronized only by women. The development in this class has been rapid and we now find large first floor establishments seating several hundred people. In the lighting of the cafeteria, one requirement cannot be made to cover the entire establishment. The dining space calls for general illumination, while the space devoted to steam tables requires a more localized lighting treatment. One of the important things to keep in mind is the protection of the eyes of those serving at the steam tables and it is found that the deep bowl type of direct lighting reflector when installed relatively low is admirably adapted for this location. Where foods are to be displayed in their true color values, the daylight lamp has an important application.

In discussing the group "C" in which the artistic predominates, we may for the purpose of convenience, divide the establishments into those that can be lighted with suspended fixtures, those for which a floor pedestal or portable arrangement is more suitable, those in which cove lighting is proper, those in which a system of bracket units would be satisfactory and those requiring a special lighting treatment.

The architectural details, as well as the lighting arrangements for the Badger room in the Hotel Wisconsin, Milwaukee, are clearly shown by the illustration in Figure 6. The indirect method

employed is supplemented by a series of pendant lights supported on the columns. The lighting fixture is designed to harmonize with the somewhat elaborate treatment of the room. The frieze is beautifully decorated with hand painted landscapes representing actual scenes from the beauty spots of the Badger State. The ceiling decorations of hand painted floral wreath designs are brought out in their full value by the lighting method employed.

An example of the most recent type is to be found in the Main Dining Room of the Brandies Department Store, Omaha, Nebr. The interior is illustrated in Figure 8. The architect in this case selected an indirect luminous bowl type fixture, the body of which is 16 inches in diameter and its over-all length 20 inches. Glass panels of the bowl are etched in colors to harmonize with the polychrome finish of the fixture and decorations. Twelve small parchment shades are mounted on candles surrounding the body of the fixture. The supporting stem is covered with cord of an orange shade to match the decorations in the room.

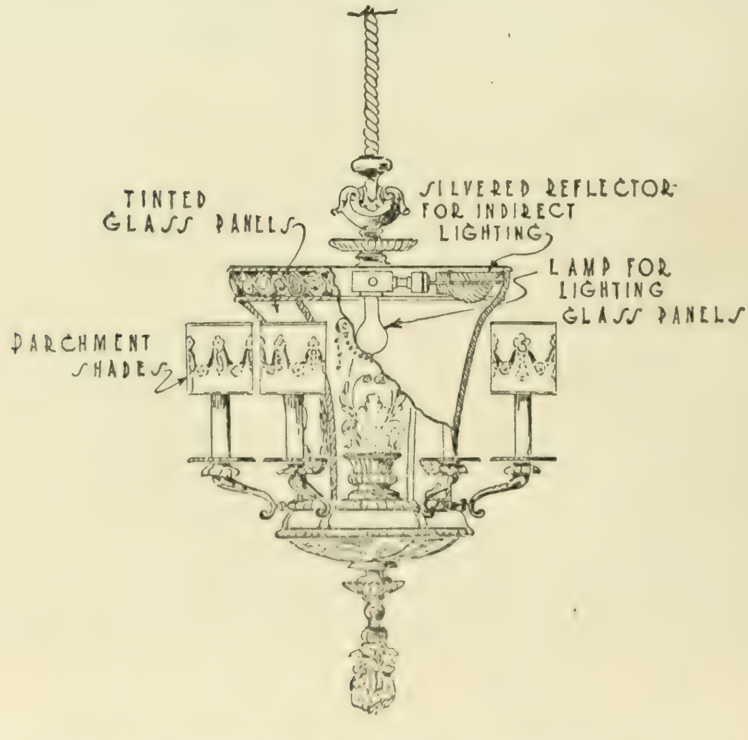

Fig. 7.—Diagram giving details of the design and interior arrangement of the Brandies Restaurant fixture.

Fig. 6.—Badger room of the Hotel Wisconsin, Milwaukee.

Fig. 8.—Main dining room of the Brandeis Restaurant, Omaha, Neb., in which the artistic treatment of the lighting unit was given careful consideration.

Fig. 9.—Unique lighting scheme to be found in the Grill of the Blackstone Hotel, Chicago, Ill.

Fig. 10.—Restaurant in which the general illumination from luminous indirect fixtures is supplemented by decorative table lamps.

A diagram is given in Figure 7 that indicates not only the general design of the fixture, but also the arrangement of the reflectors in its interior. Three lamps in silvered reflectors, burning in a horizontal position provide the indirect illumination. The candles are for decorative purposes. The fixture is wired in two circuits, the indirect reflectors on one, and the candles on the other. The glass panels of the fixture are illuminated by means of a small lamp placed in the bottom of the body supporting the indirect lighting reflectors.

A peculiar type of lighting treatment is to be found in the Grill Room, of the Blackstone Hotel, Chicago, as shown in Figure 9. The ceiling here is treated with a conventionalized relief pattern and is lighted by means of a large number of small lamps mounted on the stalactites which project into the bowls containing silvered reflectors of special design. Although the ceiling is decorated in a gray white color and fittings and furniture of the room are of the dark Elizabethan Period, the indirect illumination gives a pleasing intensity, sufficient for all purposes. Wall brackets with their lamps concealed by fabric shades add touches of light and color that assist in creating the proper atmosphere in the room.

The introduction of the table lamp to supplement the general lighting scheme, is to be found in the restaurants illustrated in Figure 10. In this case, a small lamp within the fixture serves to illuminate the glass panels and convey an idea of the luminous light source which to many, is more agreeable than the dark opaque bowl suspended against the ceiling. The spacing adopted for the units is such as to produce a uniform ceiling brightness. Sufficient intensity of light is provided and more or less distinctive effect is produced in the room.

In order to carry out the idea of flexibility, the lighting system in the club dining room of Figure 11 was carefully planned so that at least two intensities of illumination could be easily secured. A moderate intensity may be obtained by using only the candles surrounding the body of the fixture. A still greater intensity is produced when the bowl lights only are turned on and a combination of bowl lights and candles produce a brilliant lighting which is often employed when the room is to be used for special assemblies and gatherings.

A typical example of lighting of public eating places without the use of suspended fixtures is illustrated in Figure 12 which shows a tea room of a class to be found in the large cities, catering especially to the shopper and theatre goer. The lighting pedestal in this case is composed of composition, contains in its upper bowl, a number of reflectors and lamps that supply by indirect means, a flood of light throughout the entire room. As will be noted from the illustration, the decorative qualities of the lighting pedestal are enhanced by the draping of artificial flowers and vines from the upper edge of the bowl.

The application of this method can be successfully carried out in many classes of public eating places. A hotel in Milwaukee, Wis., for example has adopted this scheme, but has modified the pedestal to conform with what is to be found ordinarily in the home. The hotel dining room illustrated in Figure 13 presents a very homelike atmosphere. The architectural treatment which includes the French windows and doors, the window drapes, bracket lamps and indirect lighting portables, enhances the cozy effect. In a low ceilinged interior of this character, the lighting method that has been adopted is especially suitable. The illustration, of course, does not show the coloring that further adds to the homelike appearance of the interior.

The type of indirect lamp that is used for the lighting of the room illustrated is one of the numerous applications of indirect illumination, a system which was originally applied only to ceiling fixtures. This type of art lamp really serves two purposes, as far as the illumination is concerned. It will light the area immediately under the lamp and will also provide a clear well diffused illumination throughout the entire room. The mechanism is completely concealed within the silk shade so that the appearance of the lamp remains unchanged.

A new type of indirect portable lamp that has recently been developed is especially suitable for installations of the character just described. The details of the make up of this new lighting device are best shown by illustrations in Figures 14, 15, and 16. The mechanism consists essentially of reflector, diffuser and metal body containing sockets and switches. When a general illumination of the room is desired, pulling one of the switches turns on the large lamp contained within the opaque reflector.

Fig. 11.—Principal dining room of the Union League Club, Chicago. An installation illustrating flexibility in the lighting system.

Fig. 12.—The Hopper. A tea room lighted in an unusual manner.

Fig. 13.—Good illustration of the use of the indirect portable lamp found in the Stratford Arms Hotel, Milwaukee, Wis.

Fig. 14.—Details of a new type of indirect portable lamp suitable for illumination of dining rooms and restaurants.

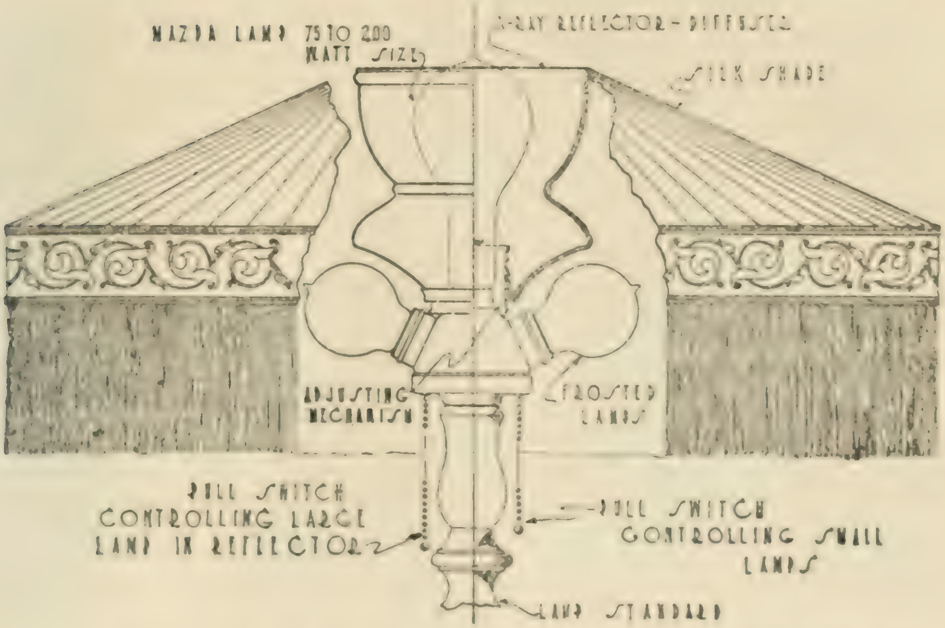

Fig. 15.—Details of a new type of indirect portable lamp suitable for illumination of dining rooms and restaurants.

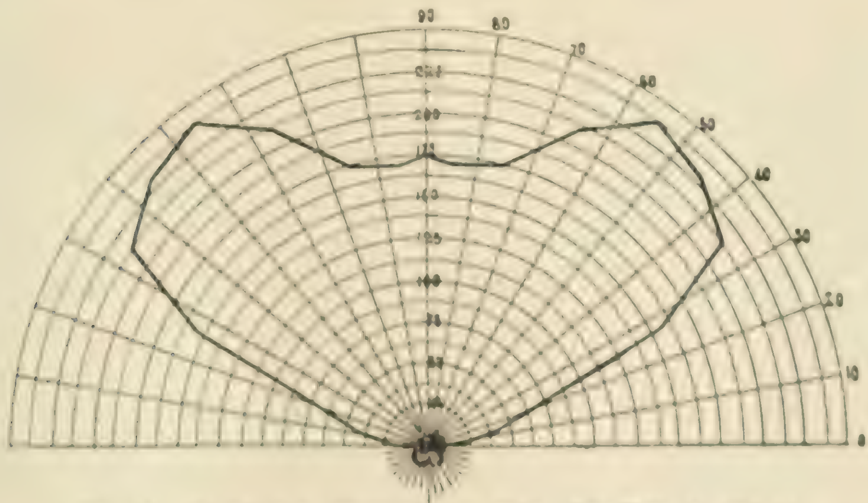

Fig. 16.—Distribution curve of new unit. See Figs. 14 and 15.

The light from this lamp is thrown to the ceiling and from there diffused throughout the room. The lower portion of the reflecting element is made of diffusing glass and assists in illuminating the shade to give the effect that is found in the ordinary art lamp.

The second switch controls the small lamps in the metal body at the base of the reflector. These lamps when used alone give

the localized lighting effect that is produced with the standard table lamp, and also serve to illuminate the shade. One of the principal advantages of this particular design is that the reflector is adaptable to lamps from the 75 to 200 watt size. The center of the filament is placed in proper relation to the reflector by merely adjusting the position of the latter on the threaded stem which forms a part of the metal body. The fact that the diameter of the reflector at the top is much smaller than for units that have been previously used for this purpose, adds greatly to the flexibility possible in the design of the silk shade.

A hotel dining room similar, as far as the lighting treatment is concerned, to that just described, is to be found in the Copley-Plaza Hotel, Boston, Mass. The illustration in Figure 17 shows this beautiful interior which is oval in shape, 60 feet wide and 80 feet long, illuminated by one central pedestal containing lamps and reflectors. An installation of this character is especially suitable since it brings out the beautiful ceiling decorations. As an additional illumination feature, lights are provided back of glass panels in the coved portion of the ceiling. It will be noted that in this particular room, no table lamps or bracket pieces are employed.

One of the most rare methods of lighting to be found in the public eating place is that of cove lighting, an example of which is illustrated in Figure 18. The architectural treatment of the room blends itself particularly to this lighting method since a natural receptacle for reflector units is provided in the upper portion of the frieze just above the side wall panels. The high arched ceiling receives the flux from the large number of small units and produces a general lighting effect which is desirable in some classes of interiors of this kind. Unquestionably the interior would be marred by suspended fixtures of any sort. Because of the proportions of the room and the location of the lighting equipment, an extremely uniform ceiling brightness is attainable, which of course, is always desirable in an installation of this kind. The main dining room shown is 29 feet wide and 118 feet long. The ceiling is 22 feet 9 inches high. Reflectors equipped with 25-watt lamps have been spaced about 12 inches apart and flexibility in the lighting has been secured by placing every third light on a separate circuit.

Fig. 17.—Copley Plaza Hotel dining room, Boston, Mass.

Fig. 18.—Public restaurant in which cove lighting method was employed with success.

Fig. 19.—Teco Inn of Minneapolis, employing bracket type fixture.

Fig. 20.—Spectacular and unusual lighting arrangement in the Alexandria Hotel, Los Angeles, Calif.

The illustration in Figure 19 is included to further illustrate the diversified methods that may be employed in the lighting of public eating places. There are certain classes of interiors for which this type of lighting scheme can be successfully recommended, especially those having low ceilings. One of the chief advantages lies in the fact that the ceiling is entirely cleared of suspended units of any kind. The interior is therefore given a more roomy appearance. The indirect lighting method also tends to raise the ceiling which is desirable in rooms of this character. All of the principal illumination in this case comes from wall brackets that have been designed as a part of the decorative columns. The exterior of the lighting bracket is made of tile and contains a non-symmetrical reflector and lamp which tend to distribute the light over the ceiling away from the unit, thus minimizing the loss on the walls and splashes of light that often occur above the bracket. Small lamps recessed in the side walls at several of the tables, add a decorative touch to the general lighting treatment.

As coming under the class requiring special illumination treatment a novel and striking scheme was once employed in the supper room of the Alexandria Hotel, Los Angeles, Cal. The lighting was accomplished by means of special indirect fixtures which were selected to permit of a better mixture of several colors than would be possible with the same number of direct lighting units.

The room with its unusual decorative scheme is illustrated in Figure 20. The walls and ceiling were decorated in a special manner with strips of white and green cloth alternating. Over the cloth across the ceiling and partly down each side wall was placed a covering of fern branches treated with ground mica. The total effect was very much as if the room were overhung with trees covered with snow. In addition, there were a number of balls from 4 to 7 inches in diameter suspended on fine wires from the ceiling. These balls were also covered with ground mica and were very helpful in getting spectacular effects when they were intercepted by the colored light of red, green and blue from the various fixtures.

The lamps and reflector equipment were housed in ornamental beaded fixtures consisting mainly of a wire frame supported by four vertical rod hangers. Blue and white beads were draped from the wire frame, sufficiently separated to permit the light from the ceiling to filter through and illuminate them. Each fixture contained six reflector units and over these units were placed supports for red, green and blue gelatine films. With dimmers in circuit, the intensity of light of the various colors could be varied at will. In addition to the colored units, each fixture contained a large individual lamp and reflector to provide the white or untinted light that was used when colors were not required.

This novel installation was used for a short season and employed primarily in connection with a skating entertainment feature. The skating rink was established at one end of the room and was also provided with special lighting features.

In many of the cafes and public restaurants, dancing is offered as the principal entertainment feature, and in almost all cases, the lighting of the dance floor is considered independently of the general illumination of the room which is usually provided with a moderate intensity. One of the simple means of concentrating light upon the dance floor is illustrated in Figure 21. In this case, projectors of the small type using 250 watt floodlighting lamps are mounted on columns near the ceiling and so directed that the illumination is confined as nearly as possible to the dance floor area. In some instances it is necessary to equip the projectors with shields to prevent a spill of light into the area occupied by the tables. The diagram in Figure 22 gives the details of a typical installation of this character. Standard equipment can in most cases be used for producing the effects desired. There are cases, however, in which spotlights are used to concentrate upon the dance floor when special exhibitions are given.

The floodlighting method has been very successfully used for several types of outdoor gardens such as the one illustrated in Figure 23. The principal illumination for the garden is received from projectors mounted on the trees and on adjacent buildings. A moderate intensity of illumination is all that was found necessary supplemented by touches of color from festoons of lamps having balloon type globes of gelatine.

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Fig. [illegible].—View in Cafe de Paris, New York, illustrating use of floodlighting projectors for illuminating dance floor.

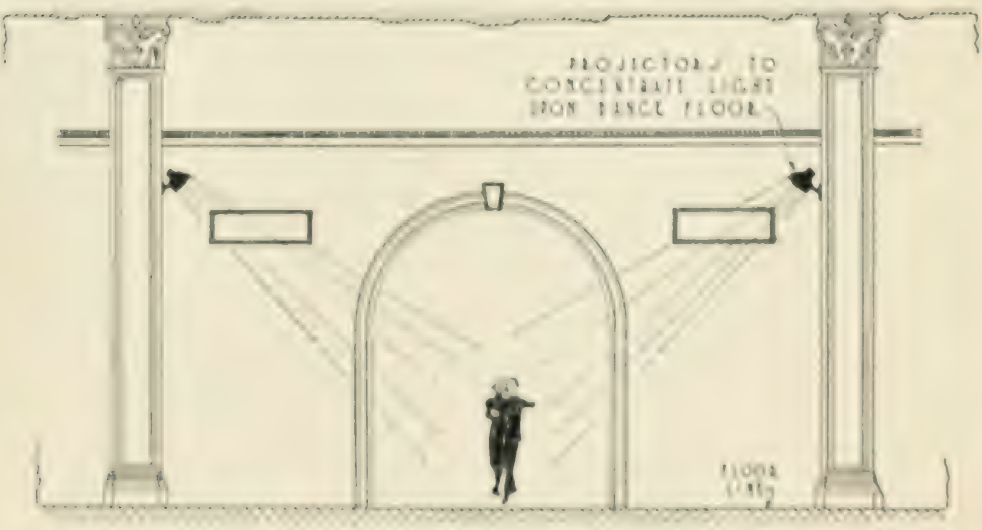

Fig. [illegible].—Diagram showing proper location for projector units for illuminating dance floor area.

Fig. 23.—An outdoor amusement garden lighted by means of flood-lighting projectors supplemented by festoons of colored lamps.

Fig. 24.—Typical restaurant kitchen using a luminaire of the enclosing glass type.

THE KITCHEN

There is a portion of the public eating place, a department of great importance, one which adds much to the comfort and pleasure of the patron, which is practically never seen by him. This is the kitchen. (See Figure 24). Many places pride themselves on the condition of the kitchen, invite inspection by guests and patrons, and consider that the sanitary and efficient arrangement is one of the best advertising features of the establishment.

There is no argument as to the part that good lighting plays in the planning and equipping of the kitchen quarters. There is no better aid to sanitation than sufficient light and there is no better tool to help the chef and his assistants in giving prompt service.

The requirements of the kitchen as far as the lighting is concerned, are purely utilitarian. There is very little call for artistic treatment in the lighting fixtures and practically only one instance in which color plays a part in the illumination and that is in the inspection of vegetables, butter and other materials that are used in preparing of the meals. Often times a daylight effect is desirable in order to facilitate and insure accurate inspection. Under some forms of artificial lighting, defects and adulterations cannot be detected, which are at once discovered when the proper color value is maintained.

The systems of illumination in general use for kitchens employ the direct and indirect lighting methods. The style of fixture that seems to be the most satisfactory for use where maximum visibility is demanded, is a deep bowl reflector containing a 100 or 150-watt gas filled lamp. The points which require special attention are the dishwashing unit, ranges, tables where salads and desserts are prepared, as well as the meat cutting and preparing tables. In most cases a wattage expenditure of 1 watt per square foot will provide plenty of light for all operations. When open reflectors and shades are used, the gas filled lamps should be treated with a translucent coating of white enamel on the bowl where there is any chance that the lamp will come within the line of vision of anyone working in the kitchen quarters. Indirect lighting has been very successfully used in many kitchens, especially with the totally opaque type of unit.

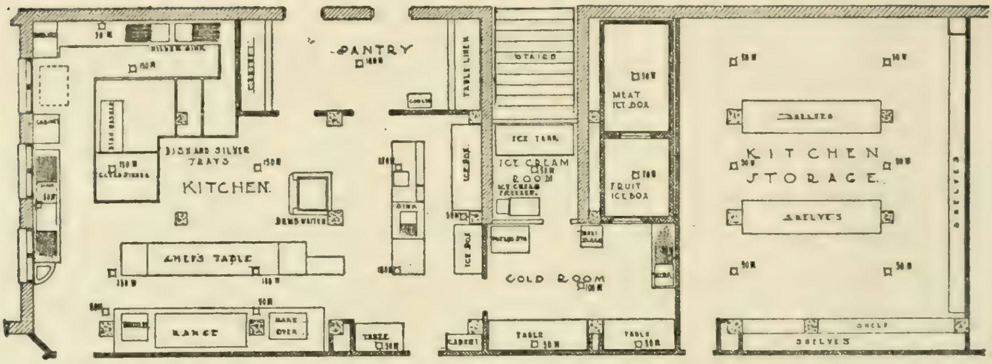

Fig. 25.—A floor plan of typical kitchen for club dining room showing various departments and proper location for lighting units.

The floor plan of a club dining room kitchen is shown by the diagram Figure 25 and includes such typical spaces as kitchen proper, kitchen storage, cold room, refrigerating plant room, pantry, ice cream room, meat ice box, fruit ice box, dish washing department, etc. The location of various lighting units is indicated by symbols on the plan. By the proper placing of units, provision is made for the general illumination of the space, as well as concentration of light at locations where the work requires close observation or inspection. In general, ceiling units are equipped with 100 or 150-watt lamps. In the storage rooms, the size of lamp is reduced to about 50 watts. In bracket lights, 50-watt lamps are usually large enough to take care of local illumination over work tables that are placed near the wall.

GENERAL NOTES ON INTENSITY

It is interesting to compare the recommendations that have been made for intensities of lighting in public eating places, with those actually found in restaurants, cafes and lunch rooms.

By taking averages of the recommendations to be found in the current books on illumination, the bulletins of the lamp manufacturers, and the hand books of associations such as the National Electric Light Association, we find that for cafes for instance, an average of 3 foot-candles is specified as desirable, for dining rooms, 3½, for restaurants 4, for lunch rooms, slightly less than 4, kitchens about 3½ and lobbies and rest rooms in connection with restaurants, slightly more than 3. In other words, a general average of less than 4 foot-candles for public eating spaces.

A hasty survey of the number of representative establishments in Chicago, gives us the following information as far as intensity measurements are concerned. Lunch rooms of the cheaper class average 2½ foot-candles. Standard lunch room 4½, cafeterias 4, club lunch rooms 6, hotel dining rooms 5, commercial restaurants 4, restaurants of specialized type such as Chinese restaurants, etc., 2, department store restaurants 1½, tea rooms 1. It is impossible to draw conclusions from the survey without taking into consideration the nature of the various establishments visited. In general, however, the average intensity found exceeds that recommended in the various hand books and bulletins mentioned in the previous paragraph. Another general statement can be made, that those places in which the artistic is emphasized and an endeavor is made to secure an atmosphere, the average intensity is much lower than in the commerical types of eating places.

An old aphorism states that "The destinies of nations depend upon the character of their diet." Why not add a modern paraphrase and say that "The destinies and nations depend upon the conditions under which they dine." We know that in all ages many of the gravest political and social questions have been settled at the dining table. Responsibility of the lighting man in providing proper conditions as far as illumination is concerned, is therefore evident.

PRACTICAL APPLICATIONS OF THE PRINCIPLES OF SCHOOL LIGHTING*

BY HENRY B. DATES**

SYNOPSIS: The lighting of many of our school buildings is far below the standards prevailing in commercial and industrial establishments. In Cleveland, Ohio, the School Board recognized the fact that in many of its schools poor lighting was prevalent. A survey was made of one hundred and twenty-three school plants of the system, and results indicated that seventy-four buildings were inadequately lighted. To correct this condition of affairs, Outhwaite School, a building typical of the general conditions to be met, was selected as a working laboratory. Many units were installed, four and six outlets per room, and thoroughly tested for various factors. This study led to the adoption by the Cleveland School Board of specifications for a standard unit and lay-out for use in the public schools.

The author has presented some interesting data and made use of typical illustrations, and has suggested specifications for enclosing globes of diffusing glass for school rooms. The standard specification for Class Room Fixture Type "E" as adopted by the Cleveland School Board is also incorporated in the paper.

At a conservative estimate twenty-five per cent of school children suffer from defective eyesight. Investigations by national and local committees to ascertain the status of vision among school children and the factors responsible for eye troubles have been practically unanimous in their findings. The reports show an intimate relation between defects in eyesight and school life; a seriously large percentage of children with eye troubles, and a marked increase in defective vision during school life. A recent report on rural schools in a large state says, "A great majority of school children have eye trouble," and, defining a reasonable standard of school lighting the report further says that only nineteen out of one hundred rural schools meet this standard. The economic loss resulting from defective vision is as yet too little appreciated. That this loss is large and of vital importance both to the individual concerned and to the industrial welfare of the country is without question.

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**Department of Electrical Engineering, Case School of Applied Science, Cleveland, Ohio.

One of the large contributing factors to the impairment of eyesight is the poor lighting of the class rooms, both natural and artificial. While most of the large cities are building, at the present time, well designed and well lighted school buildings, the general condition throughout the country is of a low average and it is appalling to find, especially in the smaller communities, new buildings being erected in which little or no attention is given to the proper lighting of the class rooms, especially with regard to artificial lighting. It is stated on competent authority that with few exceptions, state laws are deficient with regard to natural lighting, that a large number of states still have no laws governing the construction of school buildings, and that still fewer states regulate, in any way whatsoever, artificial lighting.

In the northern zones where there is a great deal of cloudy weather, natural lighting is inadequate many days in the year and must, therefore, be supplemented by artificial lighting. The artificial lighting becomes, therefore, a prime factor in reducing eye strain and must not only be adequate in quantity, but so distributed as to meet the well known and established standards of good lighting.

It is not the purpose of this paper to treat of the theoretical aspects of illumination, of the various systems available, or of the design of illumination systems. These matters have all been discussed at length in various articles and publications and are well known to illuminating engineers. This paper is rather intended to discuss the artificial lighting problem as found in one of the large cities of the country; to indicate the scope and magnitude of the problem, the method of attack and the practical outcome of a rather extensive investigation in the lighting of the school buildings of the city.

There are one hundred and twenty-three school plants in the Cleveland School System. A survey of the plants as of January 1, 1921, showed that there were seventy-four buildings in the system in which the artificial lighting was markedly inadequate. The other buildings might be classed as fairly well lighted. These for the most part, included the newer school buildings and they

had been equipped with fixtures using chiefly types of enameled and crystal glass enclosing globes[1] and open type bowl-shaped opalescent glass, semi-indirect units.[2]

A considerable number of new buildings were in course of construction and others were in process of design in the architect's office. No standard plan had been adopted for the lighting of the school buildings and various numbers of units per room and a considerable variety of glassware had been used from time to time as buildings were erected.

In the organization of the executive work of the Cleveland schools the architect's office is in charge of the planning and construction of new buildings and the Superintendent of Buildings is in charge of the maintenance and renovation of buildings after they are erected.

It was recognized that there was a pressing necessity for eliminating the defective condition in the lighting of the seventy-four buildings just mentioned and it was the desire of the Director of Schools and his staff to adopt some standard plan for the lighting of new buildings, which plan could also be adopted in the renovating and lighting of the older buildings of the system. A considerable number of proposals had been made by various interested parties as to the system to adopt, the number of units to use per room, the size of lamps, the style of glassware. It was appreciated that a careful study of the conditions was necessary before deciding upon the exact plan to follow and as there was no illuminating engineer attached to the staff of the schools, the writer was asked to make a survey of the problem and make recommendations.

To this end, Outhwaite School, a building situated in a rather congested district, typical of the general conditions to be met in Cleveland as to smoke and dirt and consisting of an original building of the older type with an addition of a more modern design was selected as a working laboratory. The various dealers in lighting fixtures and supplies were advised by the Board of Education that they could submit samples of glassware for this study and as this building contained rooms having both four and six outlets per room, complete equipments of all of the units submitted were installed in both types of rooms.

[1] Phoenix, No. 11812.
[2] Ivanhoe Regent Druid 3031.

The mounting heights were specified and were uniform in all cases. The fixture holder used in all installations was the standard school holder and conformed to the specifications of the architect's office.

The qualities considered in the study of the installations were:

(a) The intensity of the illumination on the desks.
(b) Uniformity of distribution.
(c) Density of shadows.
(d) Location and number of units.
(e) Surface brightness.
(f) Degree of glare.
(g) Depreciation due to dirt.
(h) Ease of maintenance.

The installations included among others, the following:

One type of enameled glass enclosing semi-indirect units,[3]

One type of metal and glass open semi-indirect unit,

One type of prismatic glass enclosing semi-indirect unit,

One type of prismatic glass open semi-indirect unit,

Four types of enameled and crystal glass enclosing direct lighting units,

Six types of opalescent glass enclosing units of various shapes.[4]

One hundred-watt lamps were, at this time, in use in all of the schools and at the request of the department in charge of the tests, the first studies were made using six units per room with 100-watt clear lamps in each unit and four units per room with 150-watt clear lamps in each unit. The rooms averaged about 28 feet x 32 feet, there being, as usual, some difference in the actual floor area in the rooms of the same building, the actual floor areas running between 875 and 930 square feet. The mounting heights were in practically all cases 9 feet ten inches.

The rooms having six units installed averaged approximately 900 square feet floor area. Neither the walls nor ceiling had been re-painted for six years. The color of the walls was a light buff, in rather a soiled condition, and the ceilings were of a medium cream more or less dirty. Outhwaite building is used as a grade school. The average height of the desks was two feet, and all illumination readings were made on a working plane two feet from the floor.

[3] Three sizes tested.
[4] Three sizes of one shape tested.

A very careful illumination survey was made in each room, using twenty to twenty-five stations per room, and covering practically the entire floor area. From three to five readings were made at each station. Figure 1 shows for room 202 the location

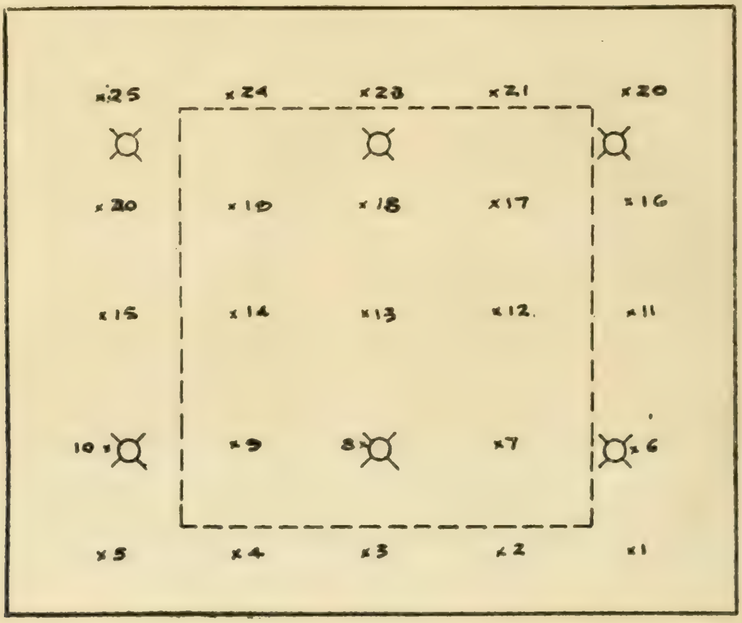

Fig. 1.—Sketch showing location of outlets and test stations in typical class room.

of the lighting units and the location of the test stations. The desk area is indicated by the dotted lines. This layout of stations is typical of that made in all of the rooms. Figures 2 to 9 inclusive show views of the various installations used in the illumination survey of the school rooms.

The following table is presented showing the average intensities, maximum intensities, and minimum intensities found in typical rooms.

A study of the data of this first series of tests showed that the distribution of light in the six unit rooms was markedly superior to the distribution in the four unit rooms. This might be inferred from the tables given above from a comparison of the maximum and minimum values of the illumination. In this series of tests it so happened that all of the four unit rooms were in the new addition where the rooms were considerably smaller. A first inspection of the data showed in most cases, an apparent superiority in average illumination in the four unit rooms over the six

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Fig. 2.—Outhwaite School, Cleveland, day view of original installation, four 100-watt bowl frosted Mazda C lamps in prismatic glass, direct lighting reflectors.

Fig. 3.—Outhwaite School, day view of original installation of bowl-shaped, opalescent glass, open, semi-indirect units.

Fig. 4.—Outhwaite School, day view of typical test installation, four-unit layout, stalactite shape, opalescent glass enclosing globe.

Fig. 5.—Outhwaite School, day view of typical test installation, four-unit layout, enameled glass enclosing semi-indirect units.

TABLE I.

Room	Unit number*	Intensities: Average	Maximum	Minimum	Watts per sq. ft.
Total power—600 watts; six unit rooms—600 watts					
106	1	3.14	4.27	2.63	0.647
101	2	3.01	4.04	1.86	0.686
202	3	2.66	4.15	1.65	0.683
103	4	2.60	3.47	1.94	0.669
201	5	2.59	4.75	1.68	0.662
105	6	2.42	3.31	1.62	0.645
101	7	2.33	3.04	1.51	0.685
202	8	2.09	2.37	1.77	0.647
102	9	1.53	1.91	1.05	0.647
Four unit rooms—600 watts					
110	5	2.81	8.00	1.52	0.777
108	6	2.74	6.60	1.43	0.765
112	7	2.74	4.40	1.55	0.773
205	3	2.64	3.72	1.39	0.650
112	4	2.63	5.60	1.45	0.773

* See Appendix C.

unit rooms, but this was due entirely to the difference in the size of the rooms and when reduced to the same floor area this superiority disappeared. The average illumination intensity was very much below values which good lighting practice indicates should be used, the highest values obtained being only 3.1 foot-candles, this with the lamps new and with the glassware clean With the depreciation due to aging of lamps and the glassware becoming dirty, the illumination would be materially below this value.

The study was, therefore, carried on using six units per room with 150-watt clear lamps in each unit. The results are found in Table II.

In addition to a study of the intensity of illumination, uniformity of distribution, glare and surface brightness, the units were very carefully examined to determine the ease of cleaning and the effect of the collection of dirt.

The surface brightness was found to range from 1.5 to 6 and 7 candles per square inch.

To determine the effect of the accumulation of dirt, six units were selected as representative of the various types. Regular

TABLE II.

Six unit rooms—900 watts					
Room	Unit number	Intensities			Watts per sq. ft.
		Average	Maximum	Minimum	
101	10	2.36	3.33	1.29	0.876
104	11	2.12	2.66	1.52	0.995
206	12	2.75	4.35	1.96	1.005
202	14	2.48	3.52	1.52	0.968
204	15	3.10	4.47	2.25	1.006
204	16	3.16	4.39	2.05	1.006
204	17	3.35	4.60	2.37	1.006
204	18	3.52	5.04	2.48	1.006
101	2	3.58	4.49	2.42	1.025
203	18	3.35	4.30	2.35	1.006
106	1	3.67	5.47	2.25	0.920
105	6	2.60	3.29	1.92	0.969

TABLE III.

Six unit rooms—1200 watts					
Room	Unit number	Intensities			Watts per sq. ft.
		Average	Maximum	Minimum	
203	18	5.00	6.20	4.00	1.34
102	19	3.36	4.06	2.55	1.259

installations of these units, four or six per room, were made and left undisturbed and without cleaning for the same period. At the end of this period careful tests were made of the illumination values before and after cleaning with results as shown below.

Unit number	Per cent increase in illumination due to cleaning
7	13.3
18	14.5
4	33.0
9	35.5
5	20.4
6	30.3
1	11.0

Cleveland is essentially a manufacturing city burning chiefly soft coal. There is, therefore, present in the atmosphere at all times, a very considerable amount of soot and dirt.

As a result of this survey and a study of the physical conditions to be met, together with the maintenance possible, it was decided that any unit selected must be consisted of a totally enclosed

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Fig. 6.—Outhwaite School, day view of typical test installation, six-unit lay-out, enameled and crystal glass enclosing direct lighting globes.

Fig. 7.—Outhwaite School, day view of typical test installation, six-unit lay-out, squat shape, opalescent glass enclosing globes.

Fig. 8.—Outhwaite School, day view of typical test installation, six-unit lay-out, enameled and crystal glass enclosing direct lighting globes.

Fig. 9.—Murray Hill School, Cleveland, night view of typical class room 33 x 22 feet, lighted by six 150-watt Mazda C lamps in squat shape opalescent glass enclosing globes, 16-inch diameter (Trojan).

piece of glass. The present financial situation does not permit repainting walls and ceilings of class rooms oftener than once in six or seven years. Before the end of this period the surfaces have become decidedly dirty and have depreciated materially in reflecting power.

The conclusion was reluctantly forced upon the investigators that under the conditions encountered in Cleveland, the depreciation of surfaces, the maintenance possible and the financial questions involved, a direct lighting system should be chosen, though for well established reasons a semi-indirect system would otherwise have been preferred. It was further decided that units of one piece of homogeneous diffusing glass were to be preferred, that the surface brightness should be kept as low as possible, and that the units selected should be of large diameter. Units 9, 10, 11, 14 were semi-indirect units and the conditions to be met were unfavorable to the semi-indirect type. The final choice narrowed down, therefore, to a very few units. These units were subjected to further critical study with regard to the distribution of light in the different zones, the surface brightness, diffusion, and freedom from glare, depreciation due to accumulation of dirt and the ease with which they could be handled and cleaned.

As a fairly extensive program of redecorating was contemplated, installations of units number 3, 18, 15, and 17 were made in Hough Avenue School, a building which had just been redecorated. These units were all 16-inch units. Sets of six units were installed in succession in the same class room with 150-watt Mazda C clear lamps. The results obtained are summarized in Table IV.

TABLE IV.

Six unit room — 900 Watts				
Unit Number	Intensities			Watts per sq. ft.
	Average	Maximum	Minimum	
20	5.88	7.71	3.54	0.99
18	5.86	7.60	3.21	0.99
17	5.74	7.23	3.39	0.99
15	5.52	7.26	2.92	0.99

It was found possible to secure glassware of homogeneous texture, having excellent diffusing properties which in the 16-inch size, with 150-watt Mazda C clear lamps gave distribution of light in the various zones, in percentage of lumens of the bare lamp as follows:

0 to 60 degree zone	25 to 28 per cent
0 to 90 degree zone	45 to 48 per cent
0 to 180 degree zone	80 per cent or better

Values of surface brightness at 35 degrees and 70 degrees ranged from 1.5 to 1.9 candles per square inch.

It was recommended that all class rooms be wired for six outlets per room, to be equipped with direct lighting fixtures and fitted with totally enclosing glassware, 16 inches in diameter. The glassware to be either Trojan or Monax 4386 or equal approved quality and used with 150-watt Mazda C clear lamps.

While the writer would have preferred to have increased the illumination intensities by the use of 200-watt lamps, which size of lamps could be used with perfectly good results in this size of unit, it was felt that the financial conditions did not warrant recommending at the time, further increase in lighting bills by the use of higher wattage lamps. However, the use of this large size globe, 16 inches, keeping as it does, the brightness to very low values, permits the use of 200-watt lamps in cases where it is desired to raise the intensity, as for sewing and other special work. The rooms are wired for two circuits per room and the wire is of ample size to permit the use of larger size lamps whenever and wherever advisable.

These recommendations were adopted by the Board of Education. Since this investigation was made, seventy-one existing buildings have been completely rewired and lighted on this plan at a cost of $291,128.24; three high school buildings are under contract for rewiring and lighting at a total estimate cost of $47,000.00; thirty-one buildings have been completely redecorated at a cost of $138,203.24. When these high schools are completed every class room in the Cleveland public schools will have been satisfactorily wired and fixtures installed, either of the totally enclosing direct type or of the semi-indirect type. This program involved the lighting of over 1,500 class rooms requiring some 9,000 lighting units. As previously stated, the semi-indirect units

are open inverted bowls in buildings which had been equipped prior to this investigation. These will eventually be replaced by units of the direct type, as it is practically impossible under present conditions to maintain an open bowl in good efficient condition and to maintain ceilings in such conditions as to make a semi-indirect system satisfactory.

Public bodies, such as Boards of Education, are obliged by law to make their purchases by inviting bids for the supplies desired, and letting contracts to the lowest and best bidder. It would be desirable in advertising for bids for lighting fixtures and glassware to have all firms bid on the same fixture and to so formulate the specifications for the glassware as to call for and require certain specific qualities.

The Cleveland School Board has adopted certain fixture designs as standard and have formulated "standard specifications for fixtures and reflectors." The specifications and the general details of the standard class room fixture are given in Appendix B.

There has not as yet been adopted in Cleveland or elsewhere, as far as is known, standards for the performance of glassware for direct lighting in class rooms.

Few cities have undertaken at one time so large a program as has been carried out in Cleveland and it is hopd that this resume of the work done in this instance may be of value to others.

The following specifications are suggested as a basis on which enclosing diffusing globes for direct lighting service might be purchased. The limits stated are put forth for discussion and very probably should be changed in some particulars.

APPENDIX A

Suggested Specifications for Enclosing Globes of Diffusing Glass for School Rooms

In the following it will be understood that the standard allowance mentioned is to be met by the average test examples, selected at random by a representative of the Board of Education.

The number of samples to be so selected and tested shall be

Lots of less than 100	2 samples
Lots of 100 or more and less than 200	3 samples
Lots of 200 or more and less than 400	4 samples
Lots of 400 or more	5 samples

The bidder shall include in his price bid the cost of making these tests at the laboratory designated by the Board of Education. The number of samples stated above is the minimum number to be tested. The bidder may, if he wishes, specify a greater number of samples to be tested.

(*A*) The total output, with a standard clear bulb, uncolored Mazda C lamp as the light source, and with the light center placed at the approximate center of the globe, should be in excess of 75 per cent without reflector over the opening; that is, the opening should be covered throughout the test with a black covering absorbing at least 90 per cent of the incident light.

(*B*) Tested as in *A*, the 0 to 60 degree zone should contain at least 25 per cent of the total bare lamp lumens.

(*C*) In the case of lighting units of substantially uniform brightness, it is most important to limit the average brightness of the entire light source. Therefore, the horizontal globe diameters in Table V are the minimum acceptable for use with lamps of the sizes and light outputs as listed.

In addition to a sufficiently low average brightness determined by the diameter of the diffusing globe, it is also important that the maximum brightness at any section to which the eye is exposed should not be unduly great. In Table V, therefore, allowances for candlepower from the brightest square inch of the globe are given for measurements to be taken at angles of 35° and at 70° above nadir. The brightness limit at 70° is restricted more closely than at 35° since high brightness at the higher angles tends to be more productive of glare. The measurement at 35° is considered representative of the zone 0° to 50°, the measurement of 70° is considered representative of the zone 50° to 90°. In case of equipment which gives evidence of unusual variations of

TABLE V.

Size of lamp	Lamp lumens	Horizontal diameter of globe in inches	Candlepower from brightest sq. in.	
			Zone 35 degrees	Zone 70 degrees
100	1300	14	3.0	2.5
150	2100	16	3.5	3.0
200	3100	16	4.5	4.0
300	4900	18	5.5	5.0

brightness over the surface, additional brightness readings in these zones may be made to determine the maximum brightness for each zone.

(*D*) Some globes which otherwise are acceptable, may be so thin in places as to not withstand ordinary handling to which they would be subjected in service. Also, it is important that the support of the globe be sufficiently strong so that there is no likelihood that the globe would fall as results of breakage of the holder lip. It appears, therefore, that a practical specification as to the weights of globes would be one which provides for resistance against breakage in handling or when supported from the holder. Some statement should be included as to the crushing pressure applied to the bottom of the globe which should be withstood by test samples, and also weights which the test globes should withstand when supported by the standard holder. No figures have yet been derived for these tests.

A means of insuring compliance with the above specifications would be, to arrange in the contract form, to subtract from the price bid, the following amounts per globe furnished if the average of the test samples falls below the standards indicated.

The light output of the globes in the 0° to 60° zone very largely determines the effective illumination in the school room It is important, therefore, from the standpoint of cost of lighting, that the unit show a satisfactory output in this zone. The specification might provide for the following penalities for non-compliance with the standard specifications of light output in the 0° to 60° zone as indicated by (*C*).

Less than 25 per cent but more than 24 per cent, subtract 10 per cent from globe price.

Less than 24 per cent but more than 23 per cent, subtract 20 per cent from globe price.

Less than 23 per cent but more than 22 per cent, subtract 30 per cent from globe price.

Less than 22 per cent not acceptable.

Upward light not only increases the cheerfulness of the appearance of the room, but also contributes to softening shadows by providing for a certain amount of well diffused illumination redirected from the ceiling. In Table VI, therefore, is given an

additional scale for deduction for non-compliance with the standard total globe output. Two ranges are given depending on whether the test globes comply in all respects with the brightness allowance or whether they fail to comply with the brightness allowance specifications.

TABLE VI.

Total globe output as determined under (A).	If globes comply with maximum brightness allowance; subtract,	If globes exceed maximum brightness allowance; subtract,
Over 75%	0%	10%
Less than 75% but 74% or more	3%	13%
Less than 74% but 73% or more	6%	16%
Less than 73% but 72% or more	9%	19%
Less than 72% but 71% or more	12%	22%
Less than 71% but 70% or more	15%	28%
Less than 70% but 69% or more	18%	28%
Less than 69% not acceptable.		

It would probably be necessary to call for separate bids for fixtures and glassware, should a penalty clause be attached to the specifications. A maximum brightness value would also need to be specified, above which glassware would not be accepted.

As stated, these specifications are in a formative stage and suggestions as to tolerances and values will be welcomed.

APPENDIX B

Standard Specifications for Class Room Fixture Type "E." Adopted by Cleveland School Board

Each fixture shall be made up of material arranged and assembled as follows:

A three-eighth inch by three- eighth inch hickey shall be screwed to a three-eighth inch iron pipe stem, then covered by a three-quarter inch diameter No. 22 B. & S. Gauge Brass Casing, that shall show no trace of seam, when finished. The casing shall be held in place at the top by the hickey and at the bottom by a smooth finished solid brass loop, which shall be screwed to the three-eighth inch iron pipe stem. This part of the fixture shall be five and one-half inches in length from end of hickey to the top of loop.

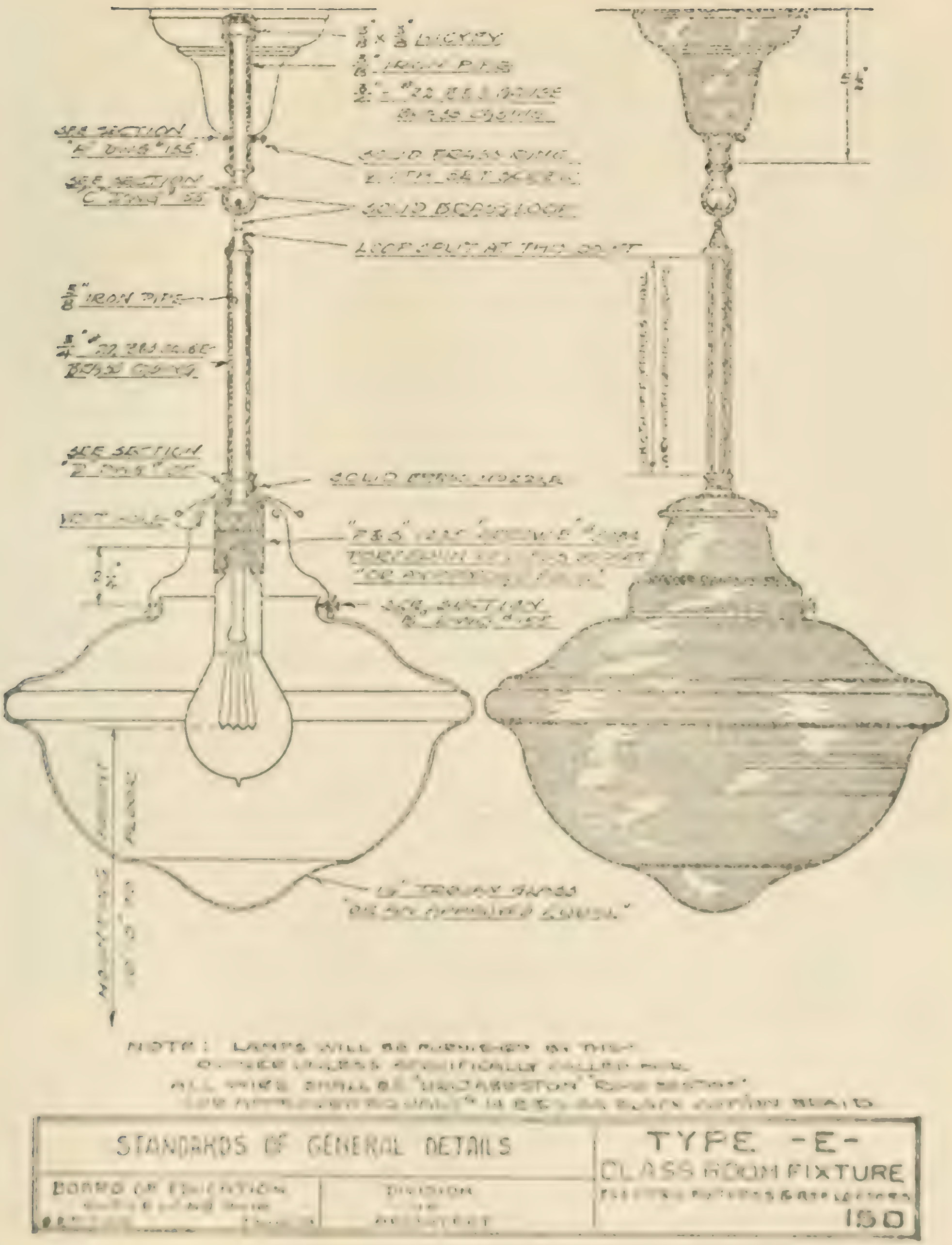

Fig. 10.—Standards of general details of Type E luminaire.

Another solid brass loop shall be screwed to three-eighth inch pipe stem, then covered by casing, as called for above. The loop shall hold the casing firmly in place at the top. At the bottom the iron pipe stem shall be screwed to a solid turned brass nozzle, recessed to receive and hold in place the casing.

The reflector holder shall be a six (6″) inch, two (2) piece spun holder, made of No. 20 B. & S. Gauge Brass and covered with white porceloid enamel on the entire inside surface. It shall be as shown in Figure 10 and the depth shall vary with other glassware than "Trojan" to bring the center of the lamp filament to the proper focal point.

The holder shall be complete, having only two (2) flanged eyelets and upset supporting screws together with an approved locking device or lock nut. The other two (2) supports shall be heavy brass studs, securely riveted and soldered in place.

The top of holder shall be flattened to permit iron cap of socket fitting up tight and in all cases the socket shall be placed against the top of holder.

Socket shall be "P. & S." No. 1235 "Arrow E" No. 5084, or equal. The location of this socket shall be such that the distance from center of holder screws to top contact in socket shall be two and three-sixteenths ($2\,{}^3/_{16}''$) inches for the "Trojan" Unit.

The glassware for this fixture shall be Ivanhoe Trojan sixteen (16″) inch, Macbeth-Evans No. 4386 sixteen (16″) inch with six (6″) inch fitter not drilled, or their approved equal.

APPENDIX C

Key to Lighting Units

No.	Name of unit	No.	Name of unit
1	3756 Monax 14″	11	Apollo
2	12″ Trojan	12	4 in 1
3	3869 Monax	14	Filterlite
4	Ace	15	Gillender Cased Glass
5	1840 Macbeth-Evans	16	Cora Cased Glass 14″
6	11812 Phoenix	17	Cora Cased Glass 16″
7	14″ Trojan	18	16″ Trojan
8	4138 Monax	19	16″ Keldon
9	14″ Keldon	20	4386 Monax 16″
10	Duplexalite		

DISCUSSION

J. A. HOEVELER: Professor Dates has already pointed out that the illumination intensities of Table II are probably too low. However, they approximate the intensities specified in the I. E. S. School Lighting Code, but when engaged in drafting the Wisconsin School Lighting Code, it was our opinion that some of these values are too low. We, therefore, are now requiring a minimum of 5 foot-candles for class rooms, and a few of the recent installations have been made on the basis of 10 foot-candles, which I think is more nearly the right value, not the correct legal minimum, but the correct desirable value.

The preferable type of natural lighting for class rooms is unilateral illumination from the left, and the reason for this choice is obvious. It seems to me therefore that we should keep this fact in mind, when concerned with the artificial lighting of class rooms. A symmetrical arrangement of the luminaires usually means that the left row of desks next to the windows will get all their artificial illumination from a direction which is predominately from the right. This is bad. Therefore in Wisconsin, we are asking for a non-symmetrical layout. Architects in general are quite willing to agree with us, even though such a layout does not look so well on the plans. Usually six outlets are provided in the standard class room (32 ft. x 28 ft.) with the entire installation offset to the left, so that the desks will receive illumination from the left. When an architect objects to this non-symmetry, his remedy is to put in a third row of luminaires, thereby restoring symmetry.

F. C. CALDWELL: It is interesting that a similar situation should have developed in Columbus, and that a rather careful study of the subject resulted in the adoption of the same type of luminaire, that is, the enclosing globe of large diameter, and comparatively shallow vertically. The tests that were made there were not so thorough as in Cleveland, and I certainly think Professor Dates is to be very much congratulated on the excellence of this investigation.

This is certainly the way to decide the type of luminaire to be used, but it is not usually adopted in the case of school lighting, where such matters are apt to be decided mainly on a basis of salesmanship. In this case, and in Columbus, the salesman did

not have much to do with it, for the unit itself determined the sale.

We investigated the units from a similar point of view. We had a unique method of deciding on the best unit. There was a committee of three; an architect, who had had considerable experience with lighting and with school design, the electrical man of the public school system, and myself. After some tests on the various units were completed, a list of characteristics was selected, somewhat similar to the ones given in this table, only more extended, and these characteristics were given different weightings, depending on what we considered were their relative importance. Each member of the committee rated the luminaires on the basis of these different characteristics, giving each a point rating between zero and ten. The points were then weighted and added and the final selection was made largely on the basis of these points.

The system was regarded as somewhat experimental and as a matter of fact, the unit with the highest number of points was an almost totally indirect unit; the same considerations as in the Cleveland case deterred us from recommending anything except an enclosing globe.

This method of judging a luminaire for a given purpose on a basis of the various characteristics, with weightings adapted to the particular purpose for which it is to be used, might be more extensively adopted. It would be well to have such a method worked out with some care, getting a consensus of competent engineers as to what the weighting should be for different purposes.

One thing which struck me with regard to this paper was the quite considerable variation between maximum and minimum in these rooms, even with the six luminaires, and it has occurred to me that it might be very desirable if some attention could be paid to the location of the pupils relative to the lighting; that is, the pupils whose eyes are not in perfect condition might be favored by being placed at the desks where the maximum lighting comes rather than placing them by chance at the desks where the minimum lighting is found.

A. L. ARENBERG: One of the reasons that has made the enclosing globe popular is undoubtedly the fact that the depreciation is very small, providing a holder is used on the fixture that is reasonably dust-proof.

I notice in these specifications in Fig. 10, Professor Dates very clearly indicates some ventilating holes in the holder. From what information we have been able to get from the lamp companies, they say that ventilation is entirely unnecessary, with globes of the size mentioned in this paper. I would therefore like to know why they put the ventilating holes in these holders.

D. H. TUCK: There are several points in this paper that are of interest to me.

First, I want to make a plea, when showing illumination measurements, as in Tables I, II, III, and IV, not to carry so many decimal places. This indicates an accuracy of an order of a tenth of one per cent, which we know we do not get in illumination measurements in the field, and I do not think those measurements should be carried past the first decimal place.

Second, this talk about brightness seems to have swept the country like fire, and many engineers seem to have lost their sense of perspective. We all know that glare is a function of brightness, total flux and contrast, but every one has forgotten about total flux and contrast. So, in this paper nothing has been said about total flux and contrast as a function of glare and the layman would assume that brightness was the only derivative of glare.

In Table V are shown permissible brightness values for various size lamps in different size globes, and it would seem from that table that a higher brightness is permissible for a large lamp. This might be the case if the lamps were hung higher, that is, if the mounting height were higher for a large lamp, but in schoolrooms the ceiling height is usually limited so the mounting height would be the same for the 100-watt or 300-watt lamp, and inasmuch as the total flux from the 300-watt lamp is much greater than from the 100-watt lamp the brightness should be less, rather than greater.

With regard to the ratings given on page 653, where the manufacturer is penalized for low efficiencies in the 0° to 60° zone, if you are going to penalize him for low efficiency, why not reward

him for high efficiency? Penalizing for efficiency below 25 per cent would cause the manufacturer to give just 25 per cent, and not try for anything better. The manufacturer therefore should be rewarded for a high efficiency in the 0° to 60° zone.

Then on page 654 the manufacturer is also penalized for efficiencies below 75 per cent in the 0° to 180° zone. We know that flux in the 90° to 180° zone is desirable. The manufacturer should therefore be penalized for low efficiencies between 90° and 180°, and he should be rewarded for higher efficiencies in the 90° and 180° zone. The 60° to 90° zone is the glare zone, and flux in that zone should be penalized. Under the system outlined in the paper, the manufacturer is rewarded; that is, he is not penalized, for high flux in the glare zone of 60° to 90°.

E. A. ANDERSON: Professor Dates mentioned the importance of the mechanical strength of the globes. It might be of interest to remark that we had occasion to make some tests of mechanical strength. In these tests we found that fixtures of standard globes of the character described in this paper seem to be able to stand anywhere from 60 to 120 pounds of steady pull. Therefore, if the globes used are of a reasonable quality there should not be much chance of their dropping. Likewise these globes seem to be able to stand a crushing pressure of from 100 to 250 pounds. Some of them, of course, will stand pressure in excess of this and I belive that some very thin samples, such as Professor Dates referred to, might have a much lower crushing strength than 100 pounds, the minimum obtained in our rather rough tests.

There is another point which I would like to make, and that is in regard to the matter of glare. My impression is that Professor Dates has succeeded very well in taking care of total light flux by specifying the large diameters of globes for the lamp sizes used. I note that he specifies a 16-inch globe for a 150-watt lamp and an 18-inch globe for the 300-watt lamp which I think is a distinct improvement upon the usual method of simply considering the brighter spot alone as the glare specification limit.

H. B. DATES: I might say there is no school lighting code in the State of Ohio; therefore, there is nothing to control this matter of school lighting. The quality of the classroom lighting depends entirely on the individual action of school boards, architects, or men who are working with them. The result is that

in many parts of the state, and frequently in towns in Northern Ohio, new school buildings are found with but one outlet in the middle of the classroom. You would be appalled at the number of schools that are going up just that way.

As regards the difference between maximum and minimum, you will find in Table IV, which gives the results that we are getting with the units we are using, that there is a ratio of about two to one between the maximum and the minimum. In regard to the larger differences you find in some of the other tables, that is due to the units. Some of the units in these tables had clear glass sections; some of them had holes in the bottom. If the station happened to come directly under a hole, the values would go right up in the scale; if the desk was over in the corner of the room, it would be way down on the scale.

With regard to that holder, I am not responsible for it. I have been trying to persuade the architect to take the ventilating holes out, but I have not succeeded as yet. We made some tests of glassware for depreciation due to dust. We put them up for six months, and those pieces of glassware that had openings in the bottom were coated on the inside with the most beautiful, greasy, black film of dirt you ever saw; those in tight holders, totally enclosed in glass were relatively very clean.

I am concerned with the matter of brightness. I want to keep the contrast between the units and the ceiling just as low as possible, so that when a child looks up he will not be conscious of the fact that he is looking at a real bright spot there—for a child will look up from his work and around the room. One way we have found of controlling this matter is to keep the size of the unit very large as compared with the wattage of the lamp we are using.

A. F. Wakefield: (Communicated). I think Professor Dates should be complimented for the interesting detail by which he has arrived at his conclusions for the use of enclosing globes for school lighting.

I believe, that in view of the paper given by Messrs. Dows and Brown at the Rochester Convention of the Society last year, we as a Society should bear in mind their most carefully derived conclusions in regard to the ventilation of enclosing units. It would seem quite in vain to us to use an enclosing globe and to finally

provide for ventilation and thereby destroy the advantages which make the enclosing globe so superior to other means of securing the proper diffusion where the units in use are not likely to receive the best attention as to maintenance.

The investigation referred to thoroughly recommends the discard of ventilation in units of this nature and because ventilation is even suggested in Professor Dates' paper it would seem that the Society has only arrived at a doubtful conclusion of this important question whereas all the evidence from the lamp manufacturers and from the investigations of our own members points to the fact that this ventilation is no longer necessary. Moreover it detracts considerably from the possibilities of a commercial lighting unit.

W. H. Fisher: (Communicated). There is some possibility that on one point in Professor Dates' paper on "School Lighting" a little confusion may occur concerning ventilation of lighting units. While Professor Dates recommends fixtures equipped with a six (6) inch fitter not drilled, in Fig. 10 two small vent holes are shown in the fitter or holder. Since these holes, which are very small, are of no practical benefit and are unnecessary, yet add to the expense of the unit, they should be omitted. Due to the fact that one manufacturer has already raised this point, it seems advisable that mention should be made of it.

ABSTRACTS

In this section of the TRANSACTIONS there will be used (1) ABSTRACTS of papers of general interest pertaining to the field of illumination appearing in technical journals, (2) ABSTRACTS of papers presented before the Illuminating Engineering Society, and (3) NOTES on research problems now in progress.

THE ELECTRICAL RESPONSE OF THE RETINA TO STIMULATION BY LIGHT*

BY E. L. CHAFFEE AND W. T. BOVIE**

It has long been known that a nerve when stimulated transmits impulses which are accompanied by electrical disturbances. If a sensitive galvanometer be connected to the sheath and core of a motor nerve which is stimulated at some distance from the connections, the electrical disturbance accompanying the nerve response consists of repeated changes in electrical potential between the core and the sheath.

When the nerve is continuously stimulated, these discrete electrical disturbances are of the same intensity independent of the intensity of stimulation but follow each other at a frequency dependent upon the stimulating effect. The frequency of impulses is of the order of a thousand per second and they travel along the nerve with a velocity of about 30 meters per second. The action in a nerve fibre can be crudely compared to the tipping over of a line of dominoes. After one electrical disturbance has traveled down the fibre the nerve is inactive even though stimulated, until the nerve energy is again built up which corresponds in our crude example to the setting up of the dominoes. It is probable that a measure of the electrical disturbances gives valuable information concerning the nature of nerve transmission.

Holmgren in 1866 discovered that an electrical change takes place in the eye of the frog when the latter is stimulated by light. Holmgren's observation was followed by many researches in which the nature of the electrical change in the retina and the optic nerve was studied.

*An abstract of a paper presented at the annual convention of the Illuminating Engineering Society, Swampscott, Mass., September 25-28, 1922.

**Harvard University, Cambridge, Mass.

It was found that when one electrode of a sensitive galvanometer is connected to the optic nerve and the other to the cornea of the eye, and the eye illuminated, the cornea became suddenly more positive in potential with respect to the optic nerve. This rapid rise in potential is followed by a decline which, however, may later change to a gradual increase. When the light is turned off the potential again rises to a maximum and falls. Einthoven and Jolly suggested that this history of changes of potential results from the action of three substances in the retina. Each of these substances gives its own electrical changes which when added give the observed curve. Waller describes the effect observed in terms of two substances.

The present investigation was undertaken to carry further the researches on the nature of vision making use of improved apparatus, a description of which follows. The eye (usually that of a frog) is excised and cut in two to remove the lens, iris and a portion of the aqueous humor. The remaining posterior half of the eyeball is then placed in a dark moist chamber and connection is made to the optic nerve and to the front surface of the retina by moist thread electrodes. These electrical terminals are carried to a two stage resistance-couple thermionic amplifier. The output of the amplifier passes to an Einthoven galvanometer arranged to record its deflections upon a moving piece of photographic paper. The deflections for various times and intensities of illumination of the eye are studied and the effects of light of different wave lengths upon the reaction are investigated.

Since the retina is a nerve net-work with special photochemical end-organs, *i. e.*, the rods and cones, and since, as has been pointed out above, the stimulation of nerves produces electrical changes which probably depict the nature of the signals transmitted to the brain, it is believed that a study of the reactions of the retina and optic nerve to stimulation by light will give a great deal of information concerning the nature of vision. The whole process of vision is, of course, extremely complicated involving first, the optical system of the eye; second, the photochemical receiving and transforming system, the retina; third,

the transmitting system, the optic nerve; and fourth, the very complex percepting mechanism in the brain. It is, of course, impossible by the present method of investigation to study the perception process and so the experiments are confined to the second and third steps in the process of vision.

The study of the typical responses of the eye to stimulation by flashes of light shows that the response curves are more complex than had hitherto been supposed. In general, there is a very rapid negative deflection followed by a rapid rise to a maximum in the positive direction (retina positive with respect to optic nerve). Subsequent to this first positive maximum there may be two to three other well defined steps or maxima in the curve. These successive maxima have been classified and denoted as the first, second and third maximum. The first occurs approximately 0.27 second after the beginning of the response, the second approximately 0.70 second, but the time to the third maximum varies with different intensities of illumination. The heights of the several maxima vary with the intensity and time of stimulation. Since the retina contains two distinct nerve terminae, rods and cones, it is reasonable to assume that the reactions of the two are dissimilar. Since the first and second maxima observed in the response curves appear to be quite independent of each other, it is also reasonable to attribute one to the cones and the other to the rods.

The height of the total response has been used as a measure of the intensity of impression upon the brain. The variation of height has been measured as the intensity of stimulation is varied and the results plotted. The results indicate that for very low intensities of illumination the response is proportional to the square root of the intensity of light. For medium intensities Fechner's law holds and for very high intensities Fechner's law breaks down. This is in accordance with psychological observation which fact gives further support to this method of studying vision.

The variations in the response curves as the eye dies have been observed and also the effect of varying the temperature. These results are qualitative and cannot easily be described with-

out the curves. In general, a frog's eye will respond for fifteen or twenty hours. A lowering of the temperature produces changes which are the same as take place as the eye ages.

The effect of the variations in the response curves has been studied when the eye is illuminated with various colored lights and the sensitivity of the eye plotted for equal intensities at various wave lengths. The frog is relatively insensitive to the red end of the spectrum and the response to the red end is much simpler and of shorter duration than the response to the blue end.

Frequently oscillations of remarkable regularity are observed in the response of the eye. These oscillations are undoubtedly associated with the separate responses of the nerves. The shape of the oscillations depend on the intensity of light and also upon the color of light and it is believed that further study of these oscillations may lead to a better understanding of color vision.

SOCIETY AFFAIRS

SECTION ACTIVITIES

CHICAGO

Meeting—October 26, 1922.

At the meeting of the Chicago Section held in the rooms of the Western Society of Engineers on the evening of October 26, Mr. Earl A. Anderson, National Lamp Works of Cleveland, presented a paper, "Some Modern Developments in Street Lighting Equipment." Various types of units, which are now in extensive use, were demonstrated. As a possibility for decorative lighting on festive occasions the use of color screens was shown and some very beautiful effects in combination with rippled glassware were secured.

The meeting was attended by a number of the members of the Electrical Department of the city of Chicago and suburbs as well as by superintendents from central station companies serving surrounding towns. About sixty-five members and guests were present.

TORONTO

Meeting—October 23, 1922.

The Toronto Chapter met in the Engineering Building of the University of Toronto on the evening of October 23, at which time Prof. G. R. Anderson gave a very interesting lecture on the "Progress of Illumination." Old and modern types of illuminants were shown and an active discussion was held. There were present twenty-four members and guests.

COUNCIL NOTES

ITEMS OF INTEREST

At the meeting of the Council on November 9, 1922, the following were elected to membership:

One Member

ARTHUR G. WEBSTER,
Professor of Physics,
Clark University,
Worcester, Mass.

Twenty-four Associate Members

L. ASCHNER,
United Incandescent Lamps & Electrical Co.,
Ujpest, Hungary.

HENRY AULER,
Architect,
F. R. A. Bldg., Washington Blvd.,
Oshkosh, Wis.

JOHN S. BARTLETT,
Lighting Representative,
Public Service Corporation,
84 Sip Ave.,
Jersey City, N. J.

J. BRAMOSO,
729 Entre Rios,
Villa Maria, F. C. C. A.,
Argentina, S. A.

J. H. CATTELL,
Secretary and Treasurer,
Warner-Patterson Co.,
914 S. Michigan Ave.,
Chicago, Ill.

RALPH W. CHADBOURN,
Edison Electric Illuminating Co. of Boston,
1165 Massachusetts Ave.,
Roxbury, Mass.

PHILIP H. CHASE,
Philadelphia Electric Co.,
2301 Market St.,
Philadelphia, Pa.

HENRY A. COOK,
Engineer,
Edison Lamp Works of G. E. Co.,
Harrison, N. J.

LEROY E. EMERICH,
Divisional Ltg. Representative,
Public Service Co.,
188 Ellison Ave.,
Paterson, N. J.

LYNN W. FERGUSON,
Sales Engineer,
Benjamin Elec. Mfg. Co.,
247 West 17th St.,
New York, N. Y.

MARCUS W. HALL,
Sales Engineer,
Duplex Ltg. Works of G. E. Co.,
6 East 48th St.,
New York, N. Y.

SUMNER R. KEYES,
Asst. Supt. Purchasing Dept.,
Edison Electric Illuminating Co. of Boston,
39 Boylston Street,
Boston, Mass.

DANIEL B. KIRBY, M. D.,
Ophthalmologist,
Bellevue Hospital,
New York, N. Y.

ROBERT M. LOVE,
Street Lighting Specialist,
Canadian General Electric Co.,
212 King Street, West,
Toronto, Canada.

JAMES H. MCQUESTON,
Lighting Representative,
Public Service Electric & Gas Co.,
271 N. Broad St.,
Elizabeth, N. J.

HENRY MAISONNEUVE,
Engineer,
Compagnie des Lampes,
41 rue La Boetie,
Paris (VIII), France.

CHARLES H. PARKER,
Supt. Generating Dept.,
Edison Electric Illuminating Co. of Boston,
39 Boylston Street,
Boston, Mass.

T. J. RIDER, JR.,
Assistant Manager,
Sunbeam Incandescent Lamp Division of G. E. Co.,
500 S. Clinton St.,
Chicago, Ill.

LELAND S. ROSS,
Great Western Power Co.,
1700 Broadway,
Oakland, Cal.

ROBERT G. ROSS,
Divisional Lighting Representative,
Public Service Co.,
80 Park Place, Newark, N. J.

HENRY A. SATTER,
Special Inspector Illumination,
New York Edison Co.,
130 East 15th Street,
New York, N. Y.

HARRY SWINDELL,
Ivanhoe-Regent Works of G. E. Co.,
5716 Euclid Ave.,
Cleveland, Ohio.

ELLIOTT W. VINCENT,
Sales Engineer,
Edison Lamp Works of G. E. Co.,
120 Broadway,
New York, N. Y.

RAY HART WILSON,
Sales Engineer,
X-Ray Reflector Co.,
31 West 46th Street,
New York, N. Y.

One Transfer to Associate Membership

DR. ELLICE M. ALGER,
40 East 41st Street,
New York, N. Y.

One Sustaining Member

CAMBRIDGE ELECTRIC LIGHT CO.,
R. M. Miller, Official Representative,
46 Blackstone Street,
Cambridge, Mass.

CONFIRMATION OF APPOINTMENTS

The appointments of the following committee members and representatives were confirmed:

As Members of the Motor Vehicle Lighting Committee

G. H. Stickney, *Vice-Chairman*
F. C. Caldwell
A. W. Devine
C. E. Godley
C. A. B. Halvorson, Jr.
J. A. Hoeveler
W. F. Little
H. H. Magdsick
W. A. McKay
A. L. McMurtry
L. C. Porter
U. M. Smith
L. E. Voyer

As Member of the Committee on Lighting Legislation

W. D. A. Evans

As Members of the Committee on Membership

J. F. ANDERSON
R. W. Everson

As Member of the Committee on New Sections and Chapters

D. McFarlan Moore, *Chairman*

As Member of the Committee on Papers

Albert Scheible

As Representative on A. E. S. C. Sectional Committee on Building Exits Code

R. E. Simpson

As Local Representative, Los Angeles, California

F. S. Mills

NEWS ITEMS

Annual Meeting of U. S. National Committee of the International Commission on Illumination

At the annual meeting of this body, held Friday, October 27, 1922, consideration was given in a preliminary way to provision for the meeting of the International Commission on Illumination which is to be held in the United States in 1924. The view was expressed that among the affiliated societies and associations which support the National Committee of this body and which are represented by it in international illumination matters, the Illuminating Engineering Society ought to bear a prominent part in the 1924 activities. It was thought that possibly the International meeting may be held near New York City and that it might be found desirable for the Illuminating Engineering Society to hold its annual convention at the same place and immediately before or after the International meeting.

Dr. E. P. Hyde is President of the International Commission on Illumination. Dr. C. H. Sharp is President of the U. S. National Committee of the International Commission.

I. E. S. Designated Joint Sponsor

By unanimous vote of the A. E. S. C. at its meeting on October 19, 1922, the Illuminating Engineering Society and the Society of Automotive Engineers were designated joint sponsors for the Automobile Headlighting Specifications.

The Council at its meeting on November 9, 1922, voted to accept this joint sponsorship.

A. E. S. C. Approves Headlighting Specifications

The specifications of Laboratory Tests for approval of Electric Headlighting Devices for Motor Vehicles, with the note referring to acetylene headlamps omitted, were unanimously approved as "Tentative American Standard" by the American Engineering Standards Committee on November 11, 1922.

These specifications were published in the TRANSACTIONS, February, 1922, as part of the Interim Report of the Committee on Motor Vehicle Lighting. The material recently approved can be found on pages 106-111 of that issue under the heading of Laboratory Tests, Section I.

Mr. John W. Lieb Honored

Mr. John W. Lieb, Vice-President of the New York Edison Company, has been informed that the King of Italy has bestowed upon him the decoration of Grand Officer of the Royal Order of the Crown of Italy.

American Delegates to I. E. C.

Gen. George H. Harries, Dr. Clayton H. Sharp, and Dr. C. O. Mailloux have been appointed members of the committee of nine representing the United States at the meeting of the International Electrotechnical Commission to be held at Geneva, Switzerland, November 18, 1922.

ILLUMINATION INDEX

PREPARED BY THE COMMITTEE ON PROGRESS.

An INDEX OF REFERENCES to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

		Date	Page
American Journal of Physiological Optics			
Some Important Physical and Physiological Relations between Radiant Energy and the Visual Apparatus and Processes—	Chas. Sheard	Oct.	391
American Journal of Psychology			
Film, Surface, and Bulky Colors and their Intermediates—	Mabel F. Martin	Oct.	451
Electrical Merchandising			
A Commercial Survey of Residence Lighting Possibilities, II—The Present Status of Fixtures and Shades—	M. Luckiesh	Oct.	66
Electrical World			
A Welcome Change of Procedure—Editorial—		Oct. 7	753
Three Desirable Qualities in Street Lighting—Editorial—		Oct. 7	754
Illuminating Engineering Society Convention Decidedly Practical—		Oct. 7	757
Journal of the American Chemical Society			
A Study of the Luminous Discharge in Hydrogen and in Mercury and a New Method of Measuring Ionization Potentials—	George E. Gibson and W. Albert Noyes, Jr.	Oct.	2091
Journal of the Franklin Institute			
Improvements in Photometric Equipment for Integrating Spheres—	A. H. Taylor	Oct.	543
Maintenance of Glass Areas in Industrial Plants—	M. Luckiesh and A. H. Taylor	Oct.	546

Licht und Lampe			
Die Beleuchtung von Schaufenstern—		Sept. 7	426
Die Wiedersterstellung Ausgebrannter Glühlampen—		Sept. 7	425
Antiker Lampenfund—		Sept. 7	427
Monthly Abstract Bulletin of the Eastman Kodak Company			
High Power Lamp (for Moving Picture Work)—	W. T. Thomas	Sept.	354
Transactions of the Illuminating Engineering Society			
Report of the Committee on Progress for 1922—		Sept.	355
The Lighting of the Milwaukee Art Institute—	H. W. Bogner and A. J. Sweet	Sept.	434
Guarding Railroad and Highway Traffic by Uniform Colored Warning Lights—	A. H. Rudd	Sept.	452
Zeitschrift für Beleuchtungswesen			
Über die Lichteinheit—	C. Muller	July	89
Eine neue Raumbeleuchtungslampe für zerstreutes Licht—	Ph. Cullmann	July	94

TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

VOL. XVII — DECEMBER, 1922 — NO. 10

The Code of Luminaire Design

THE COMMITTEE to Co-operate with Fixture Manufacturers has prepared a tentative outline of specifications and data pertaining to luminaires which is printed in this issue. In drafting this Code, the Committee confined its considerations to the utilitarian aspects of luminaires, or to those elements of design which make for proper shading, proper diffusion, and proper distribution of light. Shortcomings of luminaires are usually traceable to a lack of acquaintance with, or indifference toward, the principles which underlie the utilitarian aspects. The Code contains the material for the design of luminaires from the viewpoint of proper lighting, leaving to the designing artist the superposition of artistic lines, forms, ornaments and colors upon this scientific foundation to produce proper luminaires from the viewpoint of beauty. It is only through coördination of the two viewpoints that luminaires, desirable in the broadest sense, can be created. But in order that such luminaires be produced the artist must adapt his tools to the requirements of proper and adequate lighting even though it is necessary to evolve an original style in keeping with modern light sources and modern lighting requirements.

The Code deals with the optical characteristics of reflecting and transmitting media which form the basis for the control of light. With these characteristics in mind, the matter of light distribution is taken up in detail by showing the influence of the shape of the

shade or envelope on the distribution of light, on the efficiency of the luminaire and on the elimination of glare. A luminaire must be designed for a certain maximum output of light therefore the influence of size is discussed.

The various portions of luminaires must not exceed safe temperatures so ventilation and radiation are treated. In general, it is concluded that sufficient cooling can usually be obtained by radiation thus eliminating the disadvantages of admitting dust to the interior of an envelope which results from interior ventilation. Depreciation of light-output is discussed in connection with maintenance. Certain standardization of holders, husks, and heels are suggested. And finally an attempt is made to define various types of luminaires.

After luminaires are properly designed, often they can fail in their purpose if they are not hung in the proper position or at the proper height. It is the plan eventually to add a discussion pertaining to the installation of fixtures.

This Code of Luminaire Design has been prepared in accordance with the aims of the Illuminating Engineering Society which are to advance and to disseminate knowledge relating to proper lighting. The Committee welcomes suggestions and criticisms from designers of luminaires for, as circumstances dictate, the Code will be altered or added to from time to time.

M. LUCKIESH, *Chairman.*

REFLECTIONS

The Problem of Glare and its Need for Investigation

THE RECENT DRIVE for higher illumination as an aid to industrial efficiency has necessarily brought with it serious consideration of the question of glare, since one cannot obtain intense illumination without the use of numerous and powerful sources. Now, glare is a thing of many phases. Originally, in studying the matter, attention was chiefly directed upon the intrinsic brilliancy of the source, a factor of dominating importance when one passed from mild illuminants like the gas flame to incandescent lamps, gas or electric, of high brilliancy. More recently it has been fully recognized that the quantity of light flux independent of intrinsic brilliancy is very important, and still more recently close attention has been directed to contrast in brightness between the source and its background. For the first time in the Illuminating Engineering Society's code for industrial lighting these several factors have been taken into sufficient account and so tabulated that illuminants can be roughly evaluated with respect to their capacity for producing what in general terms we denominate glare. The data, of course, are frankly empirical, and the tabulations represent merely somewhat educated judgment as to the existence or non-existence of glare.

The thing to which we particularly wish to direct attention is the need of further investigation of the whole subject, particularly since these preliminary values are likely to arouse considerable discussion when it is attempted practically to apply them. The problem is mainly a physiological one of great intricacy to which observational values based on general impressions apply only with many reservations. Further, the fact is that the three factors of glare here noted are not in truth independent variables. The ultimate physical fact is the concentration of visual energy in the image on the retina, with a further limitation due to the absolute value of this area as compared with the light-receiving elements upon which it falls. Beyond this the matter of contrast is far from being wholly clear of the other phenomena, and all of them depend on a factor which is only intrinsically involved in the matter of background, and that is the particular state of adaptation of the eye. Inasmuch as the retinal sensitiveness varies enormously under different conditions, the background effect may or may not have large significance and the data available are as

yet somewhat imperfect. With all these limitations the tabular view of illuminants brought out in the I. E. S. code is of great practical value in classifying the rough facts, which it does from the observational standpoint in a rather complete and satisfactory way. The why and wherefore of the sensation effects here correlated can be ascertained only after considerable research, but in the larger aspect the glare tables of the code are likely to prove of immense importance in the promotion of better and safer lighting. There is much which we do not know about the theory of vision, yet it does not take much astuteness to discover when a source of light is also a source of discomfort, and therefore inevitably a source of inefficiency and of possible serious harm. *Electrical World,* November 11, 1922.

Nela Offers Fine Ornamental Street Lighting Exhibition

AT NELA PARK, Cleveland, the National Lamp Works has installed a permanent exhibit showing the twenty most efficient and popular types of standards and luminaires available for cities re-designing their street lighting systems.

From the exhibition a definite idea can be secured of the day and night appearance of the many units. Each unit is controlled by a separate switch so that any one luminaire may be singled out and its particular characteristics of light diffusion and distribution observed, or a few or all of them may be lighted at one time for the purpose of comparison.

In both beauty of design and efficiency of lighting these modern units represent a remarkable advancement over the unsightly wooden poles, with mast arm suspensions, that impair the beauty of so many residence streets, and the ball globes with small, less efficient vacuum lamps that are still in use for white-way lighting in some cities.

PAPERS

OVERCOMING DAYLIGHT REFLECTIONS IN SHOW WINDOWS*

BY WARD HARRISON AND H. T. SPAULDING**

SYNOPSIS: The reflections in the plate glass of show windows created by a bright sky or by outside objects sunlighted to a much greater brightness than those within the display, often cause annoyance by very seriously interfering with the visibility of the display and correspondingly reducing the attractiveness and effectiveness of the show window. It was found that the difficulty experienced with these reflections was overcome by lighting the objects in the display to intensities of the order of 1,000 to 2,000 foot candles. A description is given of a special lighting installation employing high power spotlights to concentrate artificial illumination on the important objects in the display. With a design of this character a practical installation showed that it was possible to obtain the necessary high intensities and do away with the objectionable reflections without an excessive wattage total

Polished plate glass under certain conditions forms a very excellent mirror. With a suitable background bright objects in front of the glass are reflected in minute detail, and many times does the magician stake his success upon the fact that the prominence of such images varies primarily with the relative brightness of the objects behind the glass and those which are reflected in it. Even with a comparatively light background reflections of objects having a still greater brightness can be seen very well. The most familiar instance of this effect is in the plate glass front of our show windows. When objects on or across the street are well illuminated the reflections are very evident in almost every window; when they are in bright sunlight and the background and trim of the window are dark, the relative strength of the reflections is such as to practically eliminate portions of the display. An effect of this character is so serious that the merchant will go to almost any length to eliminate it. Show windows, particularly those located upon an important busy street, have a high advertising value, variously estimated by different proprie-

*A paper presented at the Annual Convention of the Illuminating Engineering Society, Swampscott, Mass., Sept. 25-28, 1922.

**Illuminating Engineering Section, National Lamp Works of G. E. Co., Cleveland, Ohio.

tors at from $50,000 to $150,000 per year, $1,000 per week, $10 profit per hour, etc., depending upon the number, size and location of the windows. Without analyzing or comparing these estimates it is evident that a high value is placed upon show windows by the owners, and that whatever tends to reduce the attractiveness or visibility of the display is decidedly unwelcome.

In a number of cases an attempt has been made to do away with these troublesome reflections by the use of a curved plate glass. One of the best installations of this type is shown in Figure 1. In general this method is highly satisfactory as regards the elimination of reflections. It has not, however, been extensively employed, possibly because the use of curved glass requires that the lower edge of the glass be located from 18 inches to 2 feet behind what would ordinarily be the front line of the window. This not only gives a sense of distance to the observers, but furthermore the display being necessarily located further back receives less natural light.

It has long been realized that if it were possible to install in the window a sufficiently high intensity of artificial illumination, one which would provide a brightness of the objects in the window materially greater than the brightness of the reflected object, much of the veiling effect now encountered would be eliminated. Many have tried to accomplish this result by turning on the regular show window lights. but the results are usually disappointing. The reason for this, although frequently overlooked, becomes at once evident when one considers the relative brightnesses involved. Objects in bright sunlight, such, for example, as the buildings shown in the left hand side of Figure 4, are illuminated to perhaps 5,000 foot-candles and their images on the plate glass appear to be at least one-tenth as bright as the buildings themselves; 50 foot-candles or even 100 foot-candles of artificial light inside the window can scarcely be expected to overcome brightnesses of 500 foot-candles on the surface of the glass. Artificial illuminations of from 1,000 to 2,000 foot-candles would be of more nearly the correct order of magnitude.

The question of overcoming window reflections has been a particularly serious problem at the Lindner Company store in Cleveland on account of their location on Euclid Avenue directly

Fig. 1—Show windows utilizing curved plate glass to eliminate difficulties with reflections. Note the comparison between the curved portion of the glass and the upper part which is vertical.

Fig. 2—Interior view of window showing equipment used. One of the frames is dropped to illustrate method of access for cleaning or lamp renewals.

Fig. 4.—View of figure in window with natural lighting only and with camera so located that buildings across the street are reflected.

Fig. 5.—Conditions same as in Fig. 4 with the exception that the special lighting is added. While the reflections at the side of the picture are unchanged, those which would interfere with the view of the figure are eliminated.

Fig. 6.—View of figure in window by natural light alone with the camera so located as to show the reflections of the sky line of the street opposite the store. It will be noticed that the upper part of the figure is practically invisible.

Fig. 7.—Conditions are identical with Fig. 6 except that the special lighting is turned on.

opposite E. 14th St. In the construction of the building, therefore, the windows were made to project out in front of the upper stories and a skylight was provided in each window to increase the daylight illumination within. See Figure 2. These skylights it proved did not add a sufficient amount of light to help the situation appreciably and Mr. Helman, President of the Company, who had previously convinced himself of the futility of all ordinary means of artificial illumination set about to find a different solution. His first experiment was with a spotlight capable of producing about 25 foot-candles and was unsuccessful. However, the idea of trying to light just the principal objects in the window rather than the whole area did embody a solution of the problem and when on the advice of the authors six spotlights or floodlights of approximately 25,000 candlepower each were installed a desirable effect was secured. Ordinarily, two projectors were focused on each of the three principal costumes displayed but since the locations of objects to be lighted were not fixed, and further, on special occasions it might be desirable to direct the light from more than two projectors on a given object, it was necessary to make the installation in such a way as to provide a maximum flexibility of light direction and control. The window in which the installation was to be made was provided with a row of units along the upper edge close to the plate glass and structural conditions permitted no opportunity of substituting projectors for any of the other units in this desirable location. The window did, however, have a false ceiling which contained three removable panels of leaded glass and there was sufficient room above these to accommodate the projectors. This location was, therefore, decided upon and new panels were designed to fit the openings in the ceiling.

Figure 3 shows a detailed drawing of the construction. This consists of a special mounting for the interior glass reflector so that it can be tipped at any angle, and also a rotating circular frame for each projector which fits into the panel so that the horizontal direction of the beam can be changed as well. The main panel was fitted with a diffusing glass and the circle immediately below the projector with fluted glass to eliminate striations and give a slight vertical spread to the beam. The construction is such that it is possible to adjust the lamps from within

the window. In order to facilitate cleaning and lamp renewal, the frames were hinged at one side so that they might be lowered at an angle of about 30°. The appearance of the interior of the window with one of the frames dropped to this position is shown in Figure 2.

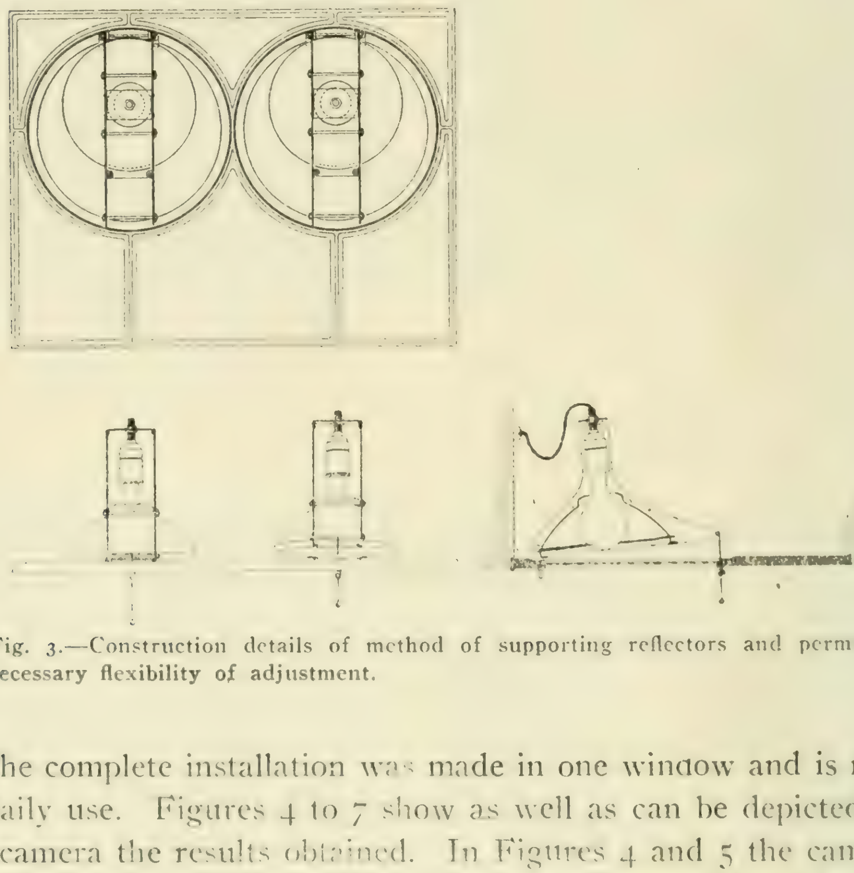

Fig. 3.—Construction details of method of supporting reflectors and permitting the necessary flexibility of adjustment.

The complete installation was made in one window and is now in daily use. Figures 4 to 7 show as well as can be depicted by the camera the results obtained. In Figures 4 and 5 the camera was located so that only buildings across the street could be reflected and inasmuch as some of these were dark in tone and were blurred when the camera was focused on the objects in the window, Figure 4 does not show the reflections as definitely as they actually appeared to the eye. This picture was taken without any artificial light in the window; the daylight intensity on the figure was approximately 100 foot-candles. In Figure 5 the special lighting was turned on. It will be noted that while the reflections are still in evidence around the sides of the picture they do not interfere with one's vision of the central figure which

becomes the most prominent object in the field of view. In Figures 6 and 7 the camera was so located that the sky was reflected in the window. In this case also the second photograph, Figure 7, was taken under the same conditions as the first, except that the lights were turned on.

The installation described above may be considered as special due to the rather unusual structural details of the show window. In many windows sufficient room is available between the upper edge of the plate glass and the ceiling to mount ordinary projector units in such a manner as to render them invisible from the street. In other windows there is enough distance between the ceiling of the window and the ceiling of the store so that they could be mounted in the ceiling in a similar manner to that described in this paper, but usually it would be feasible to locate them considerably nearer the front than was possible in this case. This would be extremely desirable since the light would then strike the front of the object to a greater extent than when located more nearly above. In some few certain cases the lighting units could be located below or at the sides of the window. The details of the window will determine in each case the best location for this special lighting.

TABLE I.—NUMBER OF PERSONS STOPPING TO OBSERVE DISPLAY WITH SPECIAL LIGHTING OFF AND ON

Time	Window A	
	Lights on	Lights off
10.15 — 11.00		45
11.00 — 11.45	93	
11.45 — 12.30		87
12.30 — 1.15	119	
2.00 — 2.30		42
2.30 — 3.00	47	
Total	259	174

The use of the high powered projectors not only made it possible for those interested in the display to see it more readily, but also the fact that the better illuminated display resulted in causing more people to stop at the window at once became evident. Table I gives the result of a very brief check on the relative number of persons who stopped to look at the display with lights on and

lights off. In a total of two hours one hundred and seventy-four persons stopped when the lights were not burning, in an equal time two hundred and fifty-nine persons or 50 per cent more stopped when the display was illuminated. It happens also that there were actually less people on the street in the second case. This is witnessed by the fact that the number of persons who stopped at another window on the street totalled two hundred and sixty-five and two hundred and thirty-eight respectively for the same periods.

DISCUSSION

The papers by Messrs. Harrison, Spaulding, Sturrock and Shute were discussed together. See page 694.

EFFECT OF LIGHT ON THE DRAWING POWER OF THE SHOW WINDOW*

BY WALTER STURROCK** AND J. M. SHUTE***

SYNOPSIS: As one branch of industry finds it profitable to increase the standard of artificial light used, all other classes consciously or unconsciously do likewise. Investigators in factories have proven that production is increased through high level lighting. Public safety is demanding that street lighting be increased and these improvements over the practice of former days induce progressive store managers to provide good lighting in their sales rooms and show windows.

To date there has been only a general impression that such lighting is really necessary. This paper is the result of tests run to obtain definite facts about the attracting power of show windows in which different intensities of illumination are used.

The investigations were carried on in Cleveland, Ohio and Newark, N. J. The data obtained gives a very fair indication of what may be anticipated under comparable conditions elsewhere.

Preliminary tests were run to ascertain the relative importance of such factors as character of display, frequency of changing display and reputation of the store.

In the main part of the tests, two windows were used simultaneously each with different levels of intensity. The lamps were so arranged that the intensities could be reversed in the two windows. Count was made of the pedestrians who looked at each window, also the total number who passed. These data, reduced to a comparable basis, are summarized in the tables presented.

With both windows lighted to the same intensity a series of tests show that as the intensity is increased, a higher percentage of the people passed is attracted. This is certainly what the merchant desires.

The attracting power of colored light is also very clearly shown by these investigations. The increase in the number of people stopping in front of the windows with colored light was in the neighborhood of 40 per cent greater than the number who stopped at the same window lighted by unmodified light from lamps of equal wattage.

The effect of light on working conditions has been demonstrated by the many factory tests which have been made in the past few years. The public has become familiar with the results obtained in industrial plants from the use of levels of illumination consider-

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** Engineering Department, National Lamp Works of G. E. Co., Cleveland, Ohio.

*** Lighting Service Department, Edison Lamp Works of G. E. Co., Harrison, N. J.

ably higher than those which had previously been considered efficient. Increases in production result from the fact that light facilitates vision. Increases in sales in stores have also been reported with levels of illumination higher than commonly employed. Sales were probably stimulated by the added attractiveness of the interior of the store.

Store managers have realized for a long while that proper lighting is an important factor in their business, and in general, this class of service is better lighted than any other. In accordance with this belief, display windows have been illuminated to high levels of illumination in order to increase their effectiveness. Although many store executives have followed this practice, it has not previously been known to what extent the drawing power of a window actually depends upon the illumination, and one did not know whether he was using light in such a manner as to get the maximum return from his show windows.

Through the courtesy of the Oppenheim, Collins and Company, arrangements were made to conduct an investigation in the two display windows of their Cleveland store. This investigation, previously reported in the technical press,[1] showed that the number of people attracted to a window depended on the intensity of illumination. In order to obtain more comprehensive data on the subject, further studies have made, not only in Cleveland, but in stores of other cities. This paper presents the results of a series of tests conducted to determine the relation of light to the drawing power of the show window.

Any display, regardless of its nature or its arrangement, is of no value unless it can be seen in detail. During the hours when daylight is insufficient for properly showing the merchandise on display, it is, of course, necessary to furnish artificial illumination. The amount of artificial illumination required has always been more or less determined from the standpoint of making the window appear brightly lighted at night. In this investigation, an attempt was made, first, to determine the actual drawing power of a window when lighted to different levels of illumination, and second, to obtain the drawing power of colored light and of spotlights.

[1] *Electrical Merchandising*, Vol. 28, No. 1, Page 96.

In approaching any engineering problem, it is necessary to reduce the number of variables to a minimum. The drawing power of the window is unquestionably dependent on several factors. These might be in brief enumerated as follows:

A—character or novelty of display
B—reputation of store
C—frequency with which the display is changed
D—method of lighting

These factors are all related, and this was proven by one of the preliminary surveys.

On the hypothesis that the apparent brightness of a show window might bear a direct relation to its attracting power (in other words, that mere bright appearance might compel attention) readings were taken of the average background brightness of some fifteen stores and check runs made on typical, widely varying conditions to determine whether the relation mentioned above existed. These rough results are presented in Table I.

TABLE I.

Store	Background	Brightness apparent Foot-candles	Intensity (foot-candles) Plane of display	Per cent of passers by attracted
1	Flat white	20.3	100	6.5
2	Flat cream	9.0	40	9.8
3	Emerald green and flat cream	1.5 and 7.0	25	7.2
4	Circassion walnut	1.1	35	13.2

There is no consistency to these figures, and a further analysis reveals, for example, window No. 1, the most brilliant of the group, fitted with a display which appeared attractive but exactly as it had been for two weeks previous to the test, attracted the least attention. Window No. 2, had a much lower brightness; the store had an equally good reputation and the display, to the casual observer, was no more attractive, yet it was regularly changed at intervals of three or four days, and the figures indicate that it attracted 45 per cent more people than window No. 1. Window No. 4, on the other hand, with a very low apparent brightness, attracted 100 per cent more people than window No. 1.

These stores were chosen with as nearly as possible the same displays, the same conditions as to surroundings and located on the same streets. Tests were conducted at these four stores simultaneously for three evenings, and the percentage of the persons attracted at each of the four stores and of those passing on the street were recorded.

The results of these tests show that, although window No. 3 was sufficiently well lighted to permit a fairly detailed inspection of the display, yet window No. 2, with a higher level of illumination, attracted more people. Window No. 1, having 100 foot-candles, was lighted better than either No. 3 or No. 2, but its display did not attract as high a percentage of the passersby because, although well arranged, it had apparently outlived its power of attraction.

It follows, from the above analysis that, one cannot lay down definite figures that a certain intensity of light will attract a certain per cent of the passersby. To obtain data of a reliable character, it is necessary to run a series of tests on one store's windows, varying the intensity and color of light. A series of tests on individual installations will give results indicating the order of magnitude which may be anticipated.

It is, of course, realized that the display itself is of the greatest importance in the show window. All other factors, such as the background and the amount of illumination are used by the store management to make a better presentation of the display. Many show windows have on display articles or objects which are of interest to the public, only from a curiosity standpoint, and of course, attract a very high percentage of the pedestrians. For example, a blank window containing nothing but a live animal will attract a very large percentage of the passersby and yet at the same time may have no advertising value to itself. In these investigations, however, windows were chosen in which a representative display of the store's merchandise was carefully and tastefully arranged to attract prospective buyers. (See Figures 1, 2, 3 and 4).

All tests were made with show windows connected with retail stores, with no changes whatever made in the nature of a special

display. Intensity of light was controlled by increasing or decreasing the number and size of lamps in service. Color changes were made through the addition of glass color caps.

It was realized early in the test that, if the observers appeared to be making notes, or particularly interested in the windows, that mere curiosity would probably attract many people. Hence, in all cases, the observers were either hidden from view or assumed unobstrusive positions where they would not attract attention. Tally was kept by means of counters hidden in the hands of the observers. During all tests, credit was given only in the event that the person either definitely stopped in front of the window or came close to the plate glass and reduced his rate of travel to a very slow walk while looking at the display. A record of all persons passing the store during a given run was kept.

I. INHERENT DRAWING POWER OF LIGHT IN THE SHOW WINDOW

After an extended preliminary survey of the subject, the conclusion was reached that the drawing power of light could be determined by illuminating two show windows of the same store to different levels of illumination and then reversing these levels. In conducting the test, each of the two windows was equipped with lamps of such sizes that either of the two levels to be used during the evening's test could be obtained by the use of one or both of the circuits. Then window A was illuminated to a given level of illumination and window B to a level of either higher or lower. Record was then kept of the number of people stopping at each window. At the end of the test period, the levels of illumination were reversed and another count was made.

In this manner the drawing power of five levels of illumination, 15, 40, 65, 85 and 100 foot-candles, was obtained. Check tests were run on these comparisons of intensities during the same evening and on different evenings. Every possible condition was obtained, tests being run on fair and stormy nights, on nights when small crowds were on the streets and when large crowds were present, on mid-week nights and on Saturday and holidays. In all, fifty test periods were run, and the number of passersby varied from 600 to 4,400 in an hour. Typical test log sheets are given in Tables II and III.

TABLE II.—CLEVELAND STORE—MARCH 1, 1922

Time	Illumination foot-candles		Individuals attracted by window		Data reduced to comparative basis		Increase due to reversing the foot-candle levels	*Increase due to changing either window alone
	A	B	A	B	A	B		
7:00-7:45 P. M.	100	40	95	122	78	100	34%	17%
7:50-8:35 P. M.	40	100	67	115	78	134		
8:40-9:25 P. M.	100	40	66	93	74	100	46%	23%
9:35-10:20 P. M.	40	100	30	71	74	146		

TABLE III.

NEWARK STORE—JUNE 8, 1922

Time	Total passers-by	Window G			Window D		
		Intensity	No. attracted	% Attracted	Intensity	No. attracted	% attracted
8:45- 9:15	605	100 f.c.	111	18.3	100	110	18.2
9:15- 9:45	580	35	59	10.2	100	80	13.8
9:45-10:15	370	100	171	46.2	35	70	18.9
10:15-10:45	230	35	39	17.0	100	51	22.0
10:45-11:15	275	100	121	44.0	35	51	18.6

* See *Electrical Merchandising.* Volume 28, No. 1, Page 96. This per cent increase was found as follows:—

The first set of data given in this Table was obtained when window A was lighted to 100 foot-candles and the other window was lighted at 40 foot-candles. The number of individuals stopping to view them during the same period of time was ninety-five and one hundred and twenty-two respectively. In order to reduce these numbers to a basis for better comparison it is found, in proportion to their ratio, that during the time one hundred persons stopped at window B, seventy-eight individuals stopped at the other window. The next set of data was obtained when the 100 and 40 foot-candle levels were reversed in the two windows. These data show that with the 40 foot-candle illumination in window A there were sixty-seven persons stopped to view it, while the other window having 100 foot-candles attracted one hundred and fifteen individuals. By reducing these numbers to a common basis for better comparison it is found, in proportion to their ratio, that one hundred and thirty-four persons would have stopped at window B during the same time that again seventy-eight stopped at the other window. It is therefore found that in this pair of tests the number of individuals stopping to view one of the displays has been increased from 100 to 134 or by 134 per cent due to the reversing of the 40 and 100 foot-candle levels in the two windows. Then the square root of 1.34 which is 1.17 gives a change for each window of 17 per cent.

Considering all windows reduced to a comparable basis by determining the relative number of people who stopped, we find, from all tests conducted, the results given in Table IV.

TABLE IV.

SUMMARY OF TESTS

CLEVELAND STORE

Average increase due to changing either window

	Per cent	No. of runs
From 15 to 40 foot-candles	24	5
From 40 to 100 foot-candles	18	9

Indicated increase due to changing either window from 15 to 100 f. c.—42 per cent

NEWARK STORE

Average increase due to changing either window

	Per cent	No. of runs
From 35 to 65 foot-candles	48	9
From 35 to 85 foot-candles	79	9
From 35 to 100 foot-candles	82	9
From 15 to 85 foot-candles	109	9

Indicated increase due to changing either window

	Per cent
From 15 to 35 foot-candles	17
From 15 to 65 foot-candles	72
From 15 to 100 foot-candles	113

It will be noted that in the case of the check test run in the Newark Store the attractive power of the windows was increased to an even greater degree with increased illumination than in the original investigation in the Cleveland Store. Although the method of test described above is such as to eliminate a maximum number of variables, nevertheless the point might possibly be raised that changes in the level of illumination do not in reality affect the total number of persons looking into the windows of any given store, but that people who intend to look in one or the other of the windows are simply diverted to the more brightly lighted of the two. To answer this criticism a second series of tests were executed in which both windows of a store were lighted at all times to the same level and these levels were changed at the same time. The criteria in this case were the percentage of passersby who viewed the windows under the different levels. Record was kept as before, and tests were conducted under all possible conditions. In some cases the windows were lighted to

one level during the entire evening's run, and on others, two or even three levels would be used during the night's test. In this way every possible method of eliminating errors and of obtaining average values, was employed. For example, on one evening, the first period would be at a high level and the second period at a low level, on the following night the first period low and the second high. The same five levels of illumination—15, 40, 65, 85 and 100 foot-candles—were used, and a total of fifty-six test periods were run.

The data obtained from two typical evenings' tests during this survey are recorded in Table V. Figures 1, 2 and 3 show, windows A and B, Cleveland Store, windows C and D, Newark Store.

TABLE V.

Time	Illumination foot-candles	Number of persons: Passing windows	Attracted by A	Attracted by B	Percentage of passersby attracted: A	B
Cleveland store No. 2—August 17, 1922						
					%	%
8:00 - 8:30	40	618	114	142	18.4	23.0
8:30 - 9:00	100	514	125	154	24.3	30.0
9:00 - 9:30	15	524	75	101	14.3	19.3
9:30 -10:00	40	357	68	89	19.1	25.0
10:00 -10:30	15	254	27	46	10.6	18.1
10:30 -11:00	100	256	55	73	21.5	28.5
Newark store No. 2—August 21, 1922						
			C	D	C	D
					%	%
8:30 - 9:00	15	914	90	82	9.8	8.8
9:10 - 9:40	35	790	106	92	13.4	11.6
9:50 -10:20	15	476	51	36	10.7	7.5
10:30 -11:00	35	390	52	44	13.3	11.2

A grand summary of all these tests is presented in Table VI on the basis of one hundred attracted at the lowest level, namely, 15 foot-candles.

These data show that, raising the level of illumination from a level of 15 foot-candles to a level of approximately 100 foot-candles, that is, in the order of magnitude of 6 to 1, caused an increase of 48 per cent in the case of the Cleveland store and 78 per cent in the case of the Newark store. Of these increases it will be noted that in the case of the Cleveland store, the increases obtained by increasing the level from 15 to 40 foot-candles and from 40 to 100 foot-candles were approximately the same. In

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Fig. 1.—Windows A and B—Cleveland Store No. 1. (*Supplied by Sturrock*).

Fig. 2.—Window C—Newark Store No. 1. (*Supplied by Shute*).

Fig. 3.—Window D—Newark Store No. 1. (*Supplied by Shute*).

Fig. 4.—Windows A and B—Cleveland Store No. 2 (*Supplied by Sturrock*).

Fig. 5.—Window C—Newark Store No. 2. (*Supplied by Shute*).

Fig. 6—Window D—Newark Store No. 2. (*Supplied by Shute*).

TABLE VI.

Illumination foot-candles	Percentage of passersby attracted		Percentage drawing power		
Cleveland store	A	B	A	B	Ave.
15	14.1	14.2	100	100	100
40	18.4	16.4	130	115	122
100	22.1	19.7	157	139	148
Newark store	C	D	C	D	
15	9.8	8.2	100	100	100
40	14.0	13.7	143	167	154
65	14.3	14.1	148	172	160
85	16.0	15.8	163	193	178

the case of the Newark store, a very large increase was obtained when the level was raised to 40 foot-candles and lesser increases were obtained above this level. This would, be expected as the ratio increases in illuminationn above this level were also lower.

2. COLOR AND SPECIAL EFFECTS IN SHOW WINDOW LIGHTING

In this test two stores in Newark were chosen, each having two display windows, outlets in each window being installed on two circuits. As in the preceding tests, records were kept of the people stopping at the windows and passing the store when different levels of illumination were supplied. In all thirty-eight check tests were made in this phase of the investigation.

In the first store one window was lighted to an intensity of 65 foot-candles and the other lighted by colored light and spots obtained from a wattage equal to that necessary to obtain an intensity of 65 foot-candles of unmodified light. In the other store, both windows were lighted to an intensity of 40 and 100 foot-candles, ten check tests being run on each of these intensities. The lamps, which were used to obtain 100 foot-candles, were fitted with glass caps of such a color as to harmonize with the display in each window and spotlights were suspended in each window to direct a beam on the central figure. (See Figures 5 and 6). Care was taken in this test that the same wattage was supplied to each window as supplied to obtain the 100 foot-candles.

Typical log sheets covering these tests are presented in Table VII.

TABLE VII.

Time	Passersby	Newark store No. 1, Aug. 28, 1922 — Window C — 65 F. c unmodified — No. attracted	Per cent attracted	Window D — Equal wattage color and spots — No. attracted	Per cent attracted
8:15-8:45	760	97	12.8	149	19.6
8:55-9:25	691	92	13.4	136	19.7
9:35-10:05	490	77	15.7	93	18.9

Newark store No. 2, Aug. 15, 1922
100 Foot-candles unmodified

Time	Passersby	Number attracted	Per cent attracted
8:15-8:45	701	85	12.1
8:50-9:20	552	69	12.5
9:30-10:00	491	59	12.0

Newark store No. 2, August 8, 1922
Equal wattage as above, color and spots

Time	Passersby	Number attracted	Per cent attracted
8:15-8:45	704	119	17.0
8:50-9:20	633	107	16.9
9:30-10:00	456	80	17.5

A summation of these tests is as follows: Newark Store No. 1 was the example used when testing the effect of intensity of unmodified light on the drawing power of the window. Here it was shown that, with both windows lighted to equal intensity, on the basis of 100 per cent attracted at 15 foot-candles, 160 per cent were attracted at 65 foot-candles. When wattage equivalent to that necessary to provide 65 foot-candles was used in colored light and spots, 220 per cent were attracted, which indicated that the attractiveness of this window was increased 36 per cent for the same wattage.

In Newark Store No. 2 on the basis of 100 per cent attracted at 40 foot-candles, 121 per cent were attracted at 100 foot-candles, and when equal wattage (100 foot-candles) was used in colored light and spots, 175 per cent were attracted, indicating that the attraction here is increased 44 per cent at a given wattage.

This test was conducted in stores in which colored show window equipment had not been previously employed. It might, therefore, be expected that the increases would be somewhat greater than

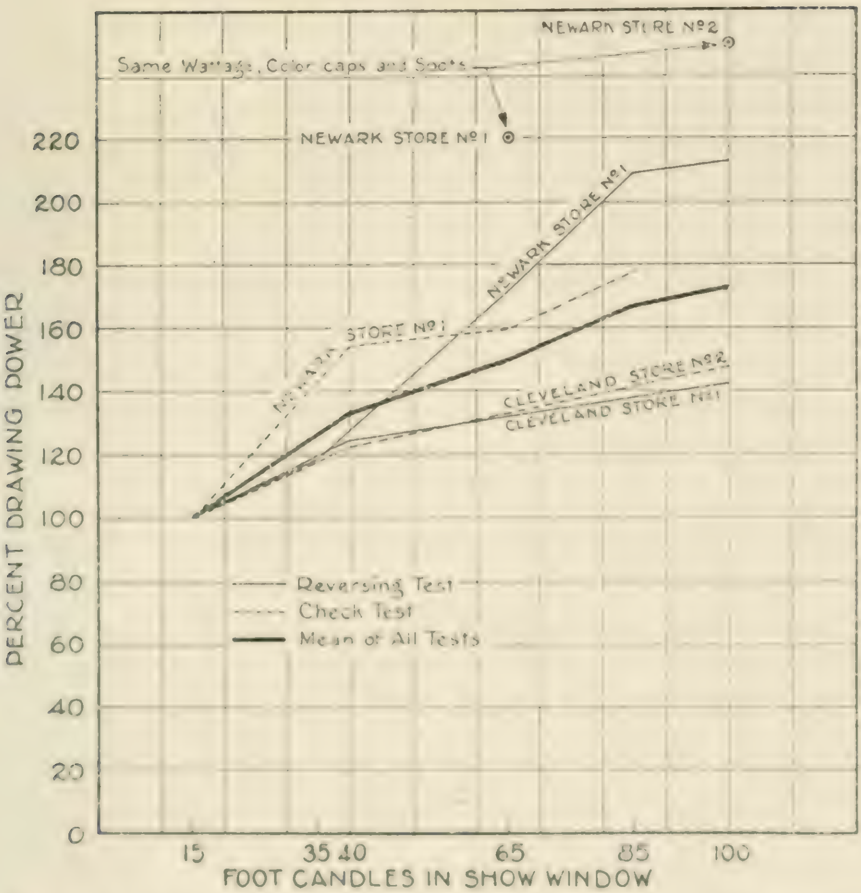

Fig. 7—Result from one hundred and six tests made in two different cities on show windows in four stores. (*Supplied by Sturrock*).

what would be obtained in a window where such equipment is regularly used. For this reason, the time of taking data was extended over a greater period than when tests of unmodified light were made. The results, however, showed that there was no apparent difference in the percentage of people attracted from the first to the last night of the test.

CONCLUSIONS

In view of the wide-spread use of show window lighting, this series of 106 tests on unmodified light, and 36 tests on colored light, though quite extensive, constitute a relatively small sample under certain metropolitan conditions. Except for the remarkable consistency of the results obtained by two different corps at considerable distances apart, the drawing of definite conclusions might be unwarranted.

Under these limitations, it was clearly evident that,

(1) As compared to fifteen foot-candles, the drawing power of these windows was increased 33 per cent by the use of 40 foot-candles and 73 per cent by the use of 100 foot-candles.

(2) That, at the same wattage, the use of colored light increased the drawing power about 40 per cent.

These experiences lead naturally to the more general conclusion that in any class of show window lighting more of the people on the street can be made to look at the display by increasing the intensity of light or through the use of color and spot light effects.

DISCUSSION

D. McF. Moore: The authors have suggested several practical ways of finding the value of light as a drawing power. Several years ago, I knew of several instances where the value of the drawing power was obtained by the merchant keeping track of his gross business per month, and when the store or the show window was lighted with one system of lighting, he would show a business in some instances—I know it was so in one or two instances—100 per cent greater than in other instances; and most merchants when they put in a new system of lighting make a note of that fact, and see whether or not it paid them to put in their new lighting.

I do not know whether or not this Society has in its Transactions a paper on that subject; if it has not, it seems to me, it would be a very practical title for a paper.

Julius Daniels: We heard of these tests made by Mr. Sturrock in Cleveland, and we ran a very similar test in Boston, in one of the larger stores on Tremont Street, which had two show windows that were exceptionally fine for this purpose. One of the windows was illuminated by twenty old 50-watt lamps and an old trough reflector, and the foot-candle intensity delivered to the window was about 10 foot-candles. In the other window we had twenty reflectors of a modern type, equipped with 150-watt Type C lamps, delivering 30 foot-candles.

In conjunction with a man from one of the jobbing houses in Boston, we carefully counted on a number of evenings the people who actually stopped and looked in each one of these win-

dows. Although the displays were better in the window that was poorly lighted, we found that 45 per cent more people looked in the window that had the higher illumination. When this fact was brought to the attention of the store, there was no question whatever about changing the lighting in the other windows.

F. C. Caldwell: I would like to raise the question as to the effect if all the stores in the neighborhood raised their window illumination to the same value?

A. L. Powell: I would like to draw attention to one feature of the scheme outlined in the Harrison-Spaulding paper, which might not occur to one as he attempts to put it in effect.

A very necessary element of this type of illumination is that the object, to be illuminated to a degree to overcome the reflections in the window, must be comparatively light in color, and have a relatively high reflection factor.

In the automobile show room a great deal of difficulty is experienced due to these window reflections and the distributors of automobiles would spend any amount of money to overcome it. We tried this scheme out, using a group of floodlighting projectors, but with the dark blues, greens and black (which are the prevailing colors on cars), the effect gained is not such as to really warrant the expenditure. However, when the car is surrounded by some sort of a light background or placed on a light floor covering which gives the effect of contrast, the difficulties of daylight reflections can be overcome to an appreciable degree by this method.

Norman Macbeth: I was attracted to this field purely from a commercial standpoint, by the amount of money that seemed to be in it, if we could do what had never been done before, and do it right.

In talking with a display manager in a store in Baltimore, I found that they had changed the backgrounds in their show windows from a painted wood to a Circassian walnut. I do not believe anyone here has any idea that the Circassian walnut would bring an additional amount of business into the store, and sell more goods, and I do not believe they thought so themselves. They just made that change so as to have the store a little better than usual. Nevertheless, that change in background cost over $40,000.

I was talking, recently, to the equipment man in a New York store about the possibility and value of increased intensity to remove the mirror reflection from the surface of the plate glass in the daytime. This would keep the "flappers" from walking up to the glass to see if their hats were on straight, and their noses powdered, and, consequently, block the view of the windows from those who really desired to see the goods displayed. He told me that the former equipment manager had spent a great deal of time and money in experimenting to do this very thing.

There are several points that come up in connection with this high intensity lighting, in the paper by Messrs. Harrison and Spaulding, where they spot-lighted single features. I believe, that in a year or two, probably less time, we will see the entire windows lighted in a similar high intensity manner.

There is one difficulty we will have to contend with, probably two,—a higher intensity of light than has ever been used before, and probably a greater degree of heat. We will get much more fading of colors in these windows, and the radiant heat will bring up problems which we have not had to consider in window-lighting. The figures, in this paper, are without heads. I wondered if the faces had been melted off the heads and the heads removed, or whether it just happened that in this store, figures without heads were usual.

I recall, some ten years ago, when a New York store increased the window lighting intensity. The man with the pure silver-lined reflector who finally got the business, was very much exercised one time, because in this particular test-window, a bottle of perfume had blown up. I suggested to him that this might be due to another of those unknown effects of the X-ray, some new reaction not heretofore recognized.

As a matter of fact, investigations have shown—I do not know if they are on record in the electrical field, but they may be found in the *Proceedings of the American Gas Institute*—that the radiant heat distribution from both gas and electric lamps compared favorably to their vertical light distribution. With electric lamps, the heat distribution is almost identical with that of the light, and of course, it is understood, that where we have light, we also have heat, but it has not been generally realized that the luminous flux is a very small proportion of the whole.

I should like to ask Mr. Harrison, if, in this particular window, the spots are used at night, that is, if they are on solely during daylight hours.

I had a case in Philadelphia, some years ago, where we provided for twice the intensity in clothing windows that was to be used in the furnishing goods windows. With this switch control, the furnishing goods window could be held down to about the same order of brightness as the clothing window. Our experience was that the furnishing goods man used all he could get, all of the time, utterly defeating the purpose of our switch control.

I found mention, upon going over some of my notes yesterday, of a case of appreciation for high intensity window lighting. In one of our Massachusetts cities, not far from here, a merchant several years ago, had a dispute with the central station, and practically cut out his window lighting. An adjoining merchant asked, "What is the matter with Jones?" (which, of course, is not that merchant's name). "Oh, he had an argument with us. He wouldn't pay his bill, and to spite us, reduced his window lighting intensity to next to nothing." "How much did he take out?" "He took out so-and-so many lamps." "Then, put them into one of my windows," he said, "and let's see that they will do." The extra lighting was put into his window, and he was so well satisfied with the effect of the increased window lighting intensity, that he afterwards ordered all his windows to be brought up to a similar level.

The doing of this thing is worth thousands of dollars to the merchant. Let us go out and do it right, if it is possible. The principle has been proven; it only remains to sell the idea in certain receptive quarters. We need a more general appreciation among lighting men of what this kind of lighting is worth to the merchant. Then, with a few good lighting salesmen who will not be afraid of the cost of doing the job right, I am satisfied that the merchant will let us light up his windows throughout, to an intensity of 1,000 to 2,000 foot-candles, provided, only, that we can assure him that it can be done, and I hope we will not have to call upon a cabinet maker or carpenter to put over the thousand-dollar idea which is necessarily associated with these 1,000 foot-candle intensities.

G. A. HOADLEY: I think no one who has seen the excellent results that are obtained by the use of curved glass windows concaved to the street in cutting down reflections could have an instant's hesitation in choosing them, if they were adapted to the display that is inside the window. We see in the illustrations given in this paper the excellent results that are obtained. I have in mind some windows of that type in Philadelphia that are used in musical instrument stores. I understand the objection to them is that they take up too much room from the street.

Would it be possible to get a similar or very nearly similar result if the glass was not curved quite so much? The difference between the perfectly plain plate glass and the one described is so noticeable that here is something that should be worked out by both the illuminating engineer and the glass manufacturer.

W. D'A. RYAN: In 1916, when we inaugurated the Path of Gold in San Francisco, the merchants of the Downtown Association asked if it would not be possible to reduce the window lighting, due to the fact we were steeping the street illumination twenty-five or thirty times upward of what it was before. I stated it would not be possible, and on the contrary they would have to increase it. After the installation had been in operation a reasonable length of time, the Downtown Association made a rough estimate of the increased window shopping due to the intense illumination of that street, and they estimated there was an increase of at least 25 per cent. I told them at that time if they would steep the window lighting up ten times and add color, they could make it 50 per cent—and that is a fact.

The drawing power of light and color is far beyond anything that the average person realizes. I trust every effort will be made so that within the next five years, window lighting will not be less than 100 foot-candles average, and I think it can be done to advantage to the public and to the merchants.

The question as to what would happen if all the lights came up to that value I think is answered by the illumination of Market Street, where the entire street level was brought up, and the window shopping increased 25 per cent, as I said before. In other words, the street is more attractive, and the hold over is worth a great deal; that is, people coming into a town where the

streets are attractive like to linger there. They figure (at least they do on the Pacific Coast) that if they can hold people over one or two more days or nights, it means quite a big advantage to the merchants and that is a point worthy of consideration.

WARD HARRISON: I have just two comments on the paper by Messrs. Sturrock and Shute. The data presented by Mr. Sturrock on the number of people attracted to the windows early in the evening and later in the evening show quite a disparity. One might think that this was simply inconsistency in test data, but as a matter of fact, I understand that they found it true in almost every test that the later the evening grew, the greater was the drawing power of very bright windows.

The other question is the one with regard to cost. Mr. Sturrock told me that the reason that he chose to stress the cost of lighting per year rather than cost per hour was because the thing the merchant worries about is not the expenditure for electricity—he knows it amounts to little in comparison with the result he gets—but he does worry about the installation cost; and in this connection, the $5,000 or $6,000 annual difference between good window lighting and poor window lighting would stand out more prominently in his mind than a figure of $3.00 per hour.

As to the paper on daytime window lighting, several have voiced a comment similar to Mr. Macbeth's, namely that we had made a good start, but that it would seem to them better in the elimination of daylight reflections to go further and light the whole window. The first difficulty in this scheme is the question of heat: a window 20 feet long would require 15 or 20 kilowatts, and that means a special system of ventilation. Mr. Macbeth pointed out that simply changing the background of a store's windows costs $10,000. Everything in a show window on a prominent street must be in keeping, and a system of special ventilation, or any other change runs into five figures very quickly.

Then there is the question of fading of goods from the use of high levels of illumination to overcome the daylight reflections. Before we were permitted to make the installation described, we tested out the effect of samples of twelve different fabrics. Strips of each were placed in front of a projector at a distance of 2 feet and kept there for two weeks. Half of each strip was

covered and half of it was exposed, and at the end of that time no line of demarcation could be detected between the exposed and unexposed portion of any sample. The test was prolonged for three or four weeks, and then the line just began to appear on some samples. I might add that the portion of each strip which was not exposed to light was also very carefully protected from the heat.

The system designed for the Lindner Company's window was based on a snap judgment that 1,500-2,000 foot-candles ought to overcome reflections and produce a desirable result. Since this paper was written further investigations have been made by the authors to determine more exactly the amount of light required to make up for the presence of the glass front in a window. A small window was so designed that the plate glass front could be quickly removed at the same time that the lights were turned off or on. The daylight illumination of the window was approximately 100 foot-candles and there were objects in bright sunlight so located as to be reflected in the glass front. The artificial illumination was raised or lowered with the glass front in place until in the opinion of the observers the window display was as clearly visible under these conditions as when the lights were extinguished and the glass removed. Fifteen observations, three made by each of five observers, showed that the addition of from 200-300 foot-candles of artificial light would just make up for the presence of the plate glass front in a window which received 100 foot-candles of daylight. These values are much lower than those upon which the paper was based. It was found, however, that though the first 300 foot-candles made up for the plate glass, the next 1,000 foot-candles were what made the window attractive. If you stand in a room illuminated to 10 foot-candles and look toward another illuminated to 1 foot-candle the latter seems dark and unattractive. Likewise if you stand on a street where the illumination is 3,000 to 5,000 foot-candles and seen an object in a window illuminated to 100 or even 300 foot-candles, it seems dim and unimpressive. On the other hand, if you have a window trimmed as in some of those slides shown by Mr. Sturrock, where there are small articles all over the window and it is not possible to concentrate on one or two, then

stepping up the artificial light to say, 200, 300 or 400 foot-candles will give an appreciable help, but the effect of 10, 20, or 50 foot-candles is inappreciable.

There was just one more point and that is with regard to Dr. Hoadley's comments on the curved glass. That seems a very clever way of accomplishing the purpose in hand, and one which entails no operating expense. I have been puzzled very much to realize that that system has been on the market for ten or twelve years, and yet I know of no city which has more than three or four such windows.

Their limited use is no doubt due to the fact that it is necessary to place the goods further back in the window where the daylight illumination drops down to perhaps 25 or 30 foot-candles, and therefore they attract few passersby.

It would appear reasonable that objects in a window receiving 2,000 or 2,500 foot-candles would be a source of objectionable glare at night. This, however, is not the case. The projectors are turned on every evening in addition to the regular window lighting and the effect is remarkably good.

J. M. SHUTE: Regarding Mr. Moore's remarks concerning the desirability of obtaining data on the merchant's findings as to business gained from better show window lighting, we have never been able to get anything really definite. Although the tests in Newark were carried on over quite a length of time, the store management have so far been unable to give us anything that we could really put into figures. However, we have noticed that since our tests were completed both the stores which we used have maintained the lighting we installed when the highest level was obtained in those stores. In one of the stores we had a system so arranged that it furnished either 35 or 65 foot-candles and the store management was in the habit of using a 35 foot-candle limit most of the time and the 65 only on special occasions. Since these tests were made they have been using the 65 foot-candle intensity at all times, and also they have paid much more attention to colored lighting since the results of the tests were explained to them.

In one store, they have spent more money on background trims, that is fixtures to go with the window display, since the

tests than they spent all the time during the test period. Not only have they kept it up in the stores that we used, but as both of these stores are owned by syndicate firms, they have asked us to help them out in bettering the lighting conditions in the windows of their other stores. One syndicate owns four stores and the other one I believe owns eight.

Besides the Boston test, about which Mr. Daniels spoke, a similar test was run in California—I think in Los Angeles. In that case the test was made in a shoe store, and they found that practically similar results were obtained. I think any man connected with lighting would be able to convince a customer very easily that he could obtain better results, by running a test similar to this.

Both Professor Caldwell and Mr. Ryan spoke of the raising of the intensity of all the stores. In the case of one of the stores in Newark, there was located on either side of it stores which had much higher intensities than were ordinarily used in the store we tested. The intensity, even when at its highest, in our store, was 65 foot-candles. The store on one side ordinarily uses about 80 and the one on the other side uses about 100 foot-candles, and in fact all the stores along that street are lighted to an average of probably 40 or 50 foot-candles.

Mr. Macbeth and Mr. Harrison both have spoken of cost figures. We figured the lighting cost out in a number of different ways and finally came to the conclusion that the cost figures per hour or per minute were so low that they indicated less to the merchant than cost figures on the same window per year.

TENTATIVE CODE OF LUMINAIRE DESIGN*

PREPARED BY

THE COMMITTEE TO CO-OPERATE WITH FIXTURE MANUFACTURERS

CONTENTS

*A paper presented at the Annual Convention of the Illuminating Engineering Society, Swampscott, Mass., Sept. 25-28, 1922.

The Illuminating Engineering Society is not responsible for the statements or opinions advanced by contributors.

PART I

THE PURPOSE OF A LUMINAIRE

The primary functions of a luminaire are usually purely utilititarian; that is, to distribute and to diffuse light adequately and properly. Furthermore it should not be a hindrance or an annoyance to vision. Having fulfilled these requisites, the luminaire then may be clothed in a great variety of ways to make it beautiful in itself and harmonious with the decorative scheme. There are luminaires and illuminated ornaments whose existence is justified solely from a decorative viewpoint. In these the distribution of light need not be considered but they should not be glaring or offensive to vision. For example, the wall-bracket with dense shields or shades in the dining-room or the living-room, the torchere, certain portables, and various lighting novelties have a right to exist as decorative objects. As such they have great possibilities. However the aim of this Code is to treat of the utilitarian aspects of luminaires, or those elements of design which make for proper shading, distribution and diffusion of light. In other words this Code does not aim to include discussions of elements which do not unduly intefere with the principles of proper and adequate lighting.

PART II

CHARACTERISTICS OF MEDIA

The materials selected for luminaires should be considered from the viewpoint of their ability to *shade*, to *diffuse*, and to *redirect* light with reasonable efficiency both when new and when in service.

SECTION 1. SHADING. The chief use of a shade is to diminish or to intercept the light from the source in certain directions where such light is not desirable. The function of the shade is commonly combined with that of a reflector although a reflector may be erroneously called a shade when it does not diminish or intercept light in those directions where the light is not desirable.

Crystal, C. R. I. and C. R. O. glasses in the usual shapes employed for shading are often erroneously referred to as shades, for usually they do not sufficiently diminish or intercept the light from the source. Among the materials which do afford a means

of shading are the denser opal glasses or their equivalent, silvered glass, parchment, textiles, enameled and painted metals.

The effectiveness of a shade, assuming a choice of proper material, is largely dependent on the position of the light-source with respect to the edge of the opening. With only this one limitation on the proportions of a shade, the designer is free to use a wide variety of designs. For example, in the case of a symmetrical pendent shade, Figure 1, the angle formed between lines drawn through the centre of the light-source to the edge of the aperture of the shade and through the axis of symmetry will be termed the angle of cut-off. If this shade is inverted as in Figure 2 the angle of the cut-off remains the same. In general in the case of symmetrical shades, bowls, etc., the angle of cut-off is one half the plane angle subtended at the light-source by the aperture.

The proper angle of cut-off is determined by the actual application of the shade which involves the hanging height, the area to be directly illuminated, the position of the eyes, etc. The design and installation of a shade should be such as to shield the eyes from the light-source at all the angles at which the luminaire is likely to be viewed. Examples of proper and improper angles of cut-off are shown in Figure 3 and in Figure 4, illustrating the satisfactory and unsatisfactory shading of light-sources.

With luminaires for so-called semi-indirect and indirect lighting, the angle of cut-off, while not directly important in concealing the light-sources, should be given consideration. With this type of luminaire the angle of cut-off usually should be small enough to confine the cone of direct light to the ceiling and large enough to avoid producing a small spot of excessive brightness above the luminaire. This point is illustrated in Figures 5 and 6.

SECTION 2. REFLECTION. A ray of light travels in a straight line until interfered with by some object or medium. This interference is usually due to reflection or to refraction or to both.

Regular Reflection—The simplest form of reflection is that which takes place when a ray of light strikes a polished or mirrored surface. Reflection of this kind obeys a very simple law stated as follows; The angle of incidence is equal to the angle of reflection.

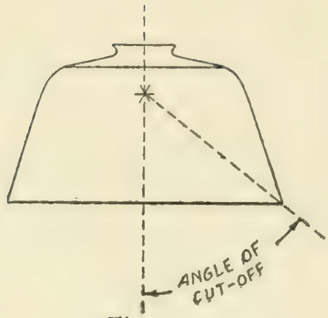

Fig. 1

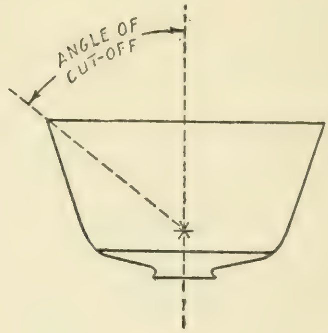

Fig. 2

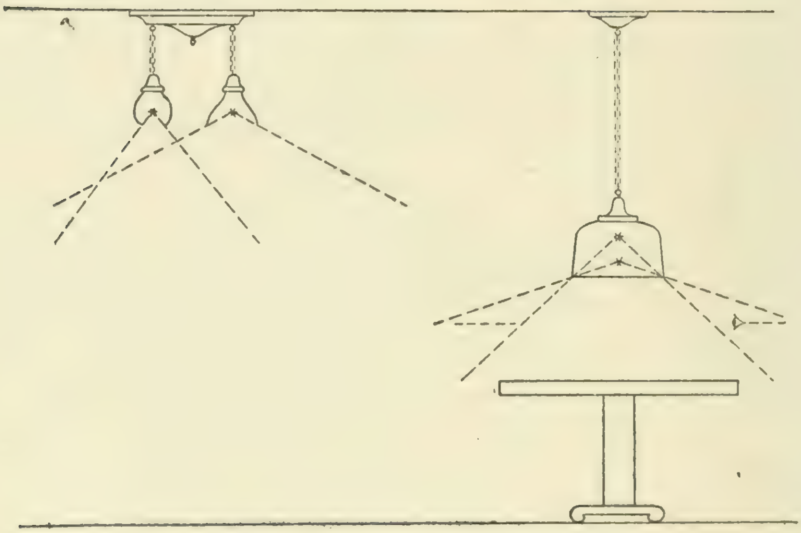

Fig. 3 Fig. 4

Fig. 5

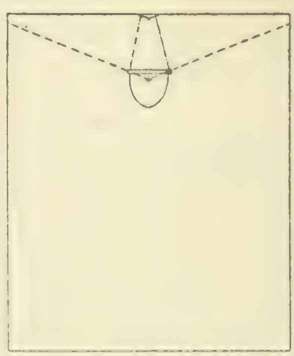

Fig. 6

Fig. 1.—Angle of cut-off of a shade.

Fig. 2.—Angle of cut-off of an inverted shade.

Figs. 3 and 4.—Proper and improper angles of cut-off.

Fig. 5.—Angle of cut-off such as to produce a bright spot on the ceiling.

Fig. 6.—Angle of cut-off such as to produce a more uniformly lighted ceiling.

TABLE I.—REFLECTION FACTOR OF THE FIRST SURFACE OF A PLANE GLASS OF REFRACTIVE INDEX EQUAL TO 1.55

Angle of incidence (degrees)	Reflection-factor (per cent)
0	4.65
10	4.66
20	4.68
30	4.82
40	5.26
50	6.50
55	7.74
60	9.73
65	12.91
70	18.00
75	26.19
80	39.54
85	61.77
86	67.82
87	74.56
88	82.10
89	90.54
90	100.00

In Figure 7, *I* represents a ray of light striking a mirrored surface, and *R* the reflected ray. The angles of incidence and reflection are indicated by I and R respectively. By utilizing this principle it is possible to redirect the light from a source in any desired direction with a high degree of accuracy.

In practice polished metals and certain mirrors made by deposition, reflect light regularly as shown in Figure 7. A polished glass surface reflects a small portion of the light regularly unless the angle of incidence is large. The results for one surface of polished glass (refractive index 1.55) are shown in Table I. These values are greater for materials of higher refractive index such as porcelain.

Diffuse Reflection.—In perfect diffuse reflection the incident beam of light upon striking the reflecting surface is scattered in many directions in such a way that regardless of the angle at which the surface is viewed it is equally bright. Perfect diffuse reflection is illustrated in Figure 8. There are many surfaces which diffusely reflect the incident light approximately perfectly. Inasmuch as the light is scattered in all directions very little control of the light is afforded by media having this characteristic. Blotting paper, plaster, roughed opal glass, "flat" paints as well as many other surfaces are diffusely reflecting.

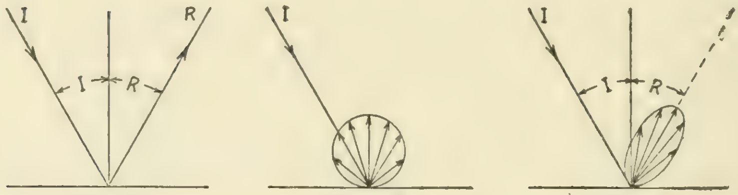

Fig. 7 Fig. 8 Fig. 9

Fig. 7.—Reflection from polished and mirrored surfaces.
Fig. 8.—Illustrating perfect diffuse reflection.
Fig. 9.—Illustrating spread reflection.

Mixed Reflection—If a diffusing surface is glazed or varnished the result is "mixed" reflection, that is, a combination of regular and of diffuse reflection. This can be illustrated by placing a sheet of clear glass upon a white blotting paper. See Figure 10.

Spread Reflection—There is a very genaral type which may be termed "spread" reflection as illustrated in Figure 9. A surface coated with aluminum paint affords a good example. When a beam of light strikes such a surface the rays are reflected in different directions but in the general direction that would be followed if regular reflection took place. The spread of the reflected light is dependent upon the degree of smoothness of the surface. The rougher or more irregular the surface, the greater the spread.

The reflection characteristics of media of this class are similar to those having polished surfaces except that the light is redirected with considerable less accuracy. The effectiveness of redirection of light increases with decreasing spread or as regular reflection is approached.

The total amount of light which may be reflected from such surfaces shown in Figures 7, 8, and 9, are about the same for the best materials of the various characteristics. For example, a good mirror and the best of white pigments will reflect about 90 per cent of the incident light, the difference being merely in the manner in which the light is redirected.

SECTION 3. DIFFUSION. Diffusion is a breaking up of a beam of light and a scattering of its rays in many directions either by the nature of the surface upon which it falls or by the nature of the substance through which it passes. An opal glass globe around a light-source is said to diffuse the light whereas in effect

the source of light has been increased in area. One of the most commonly used diffusing media is so-called opal glass. The properties of opal glass can be most easily understood if it is thought of as crystal glass containing translucent white particles or minute air bubbles.

In Figure 10, *a* represents a beam of light striking the smooth surface of a good diffusing glass, part of it being reflected regularly by the smooth surface in the direction indicated by *b* as in the case of a mirror. The remainder of the light enters the glass until it strikes the translucent white particles or minute air bubbles. The light is then scattered in many directions, some of it being thrown back and diffusely reflected and the remainder, assuming no loss by absorption in the glass, being diffusely transmitted emerging in many directions as shown. Glasses of this kind are very effective in obscuring the light-source. The transmission of good diffusing glasses may be as low as 10 per cent and on the other hand there are globes of good diffusing glass which allow from 80 to 90 per cent of the light from the source to be transmitted. In a specific case of enclosing globe only 60 per cent of the light coming directly from the light-source to a point on the surface may be directly transmitted, but sufficient light may come to this point from the illuminated interior of the globe to bring the total transmission of the globe up to 90 per cent.

A good diffusing glass need not necessarily be thick. A thin coating of a dense mixture may be "flashed" on clear glass of ordinary thickness, producing what is known as flashed opal, with resultant high transmission and good diffusion.

Besides the media which afford good diffusion, there are others which diffuse the transmitted light to lesser degrees. A diffusing medium which allows the position of the light-source to be seen without actually showing the form of the light-source may be considered as a fair diffuser while a diffusing medium which allows the outline of the light-source to be seen may be considered as a poor diffuser.

In Figures 11 and 12 the characteristics of fair and poor diffusers respectively, are illustrated. A part of the light from the source is reflected regularly from the smooth surface of the fair and of the poor diffuser just as in the case of the good diffuser.

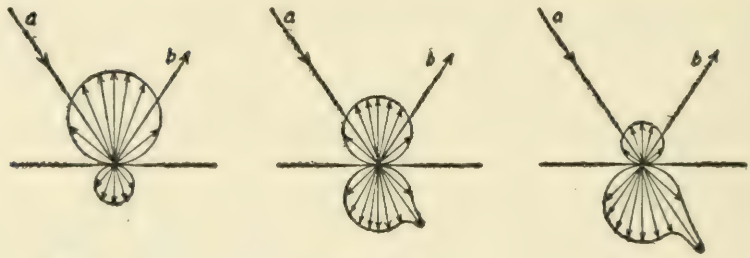

Fig. 10 Fig. 11 Fig. 12

Figs. 10, 11 and 12.—Reflection and transmission characteristics of the good, fair and poor diffusers respectively (smooth surface).

A part of the light strikes the translucent or minute air bubbles is thrown back and diffusely reflected while the remainder, assuming no loss in the glass, passes through in many directions except that more of the light passes out in a line parallel to the one along which it entered than in the case of the good diffuser. If the medium were viewed along this line this would be apparent by the bright spot in the case of the so-called fair diffuser and by the outline of the light-source with the so-called poor diffuser.

In all of these cases the smooth surface of the glass has been a means of reflecting part of the light regularly. The amount due to regular reflection at a given angle is of the same order of magnitude as that from one surface of plane clear glass at the same angle as indicated in Table I.

This may be advantageously used in designing luminaires of diffusely reflecting or transmitting media to build up the amount of light in certain directions but care should be exercised so as not to direct this regularly reflected light in those angles that are likely to be in the line of vision, for when the luminaire is viewed along the lines in which this light is directed an image of the light-source may be plainly seen.

When it is desirable to eliminate this component of regular reflection this may be done by roughening the surface by such means as sand-blasting and acid-etching. When the surface of the good, fair and poor diffusing media, adjacent to the light-source is roughed the reflection and transmission characteristics of the media are as indicated in Figures 13, 14 and 15 respectively. In such case the regularly reflected component of light indicated in Figures 10, 11 and 12 is eliminated.

In addition to the diffusion of light obtained from the class of diffusing media just described, etched crystal glass reflects

Fig. 13

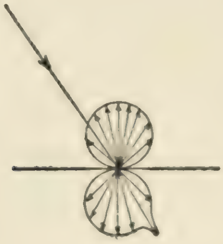

Fig. 14

Fig. 15

Figs. 13, 14 and 15.—Reflection and transmission characteristics of the good, fair and poor diffusers respectively (roughed surface).

and transmits light in a manner indicated in Figure 16. In this case the beam of light striking the roughened surface of the glass is reflected to some extent more or less diffusely. The transmitted light is scattered in many directions but mainly in a direction, more or less, parallel to that from the source. Owing to the lack of good diffusion, media of this type are undesirable for most luminaires and especially undesirable for shades. Such materials as tracing cloth and paper exhibit diffusing characteristics in varying degrees.

Fig. 16

Fig. 16.—Reflection and transmission of such media as sand blasted and acid etched glass.

The illustrations in Figure 17 indicate the scattering of light from a single small source when transmitted through glasses such as ribbed, pebbled, etc.

Diffusion in addition to scattering light may be a contributing factor in reducing the brightness of sources to that within the limits of comfort. Diffusing also affords a means of reducing shadows. Without diffusion, shadows, due to luminaire parts such as supports and chain, are thrown on the ceiling and other surroundings. To minimize this the luminaire should either utilize diffusing media around the source or diffusing bulbs, such as the frosted, coated and opal-glass bulbs should be used.

SECTION 4. REFRACTION. Transparent and translucent substances have the property of refracting light. Various substances differ in their optical properties. In general when a beam of light passes from one medium to another its path will be somewhat altered. Refraction may be said to be the bending of a beam of light as it passes from one medium to another differing in optical density or refractive index. A common illustration of this may be noted when a fish-line is partly in air and partly under water. In this case the line appears to be changed in direction at the point where it enters the water. The line may be straight but the light rays coming from that part of the line under water are refracted when they pass from the water into air. Optical text-books supply the formula and data necessary for computing refraction.

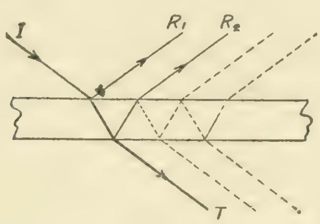

Fig. 18

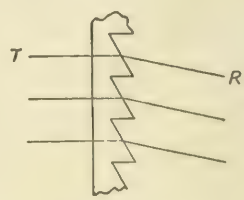

Fig. 19

Fig. 18.—Illustrating reflection and refraction of light by plane polished glass.
Fig. 19.—Refraction of prism glass.

An illustration of refraction when light passes from air to glass is presented in Figure 18. A ray of light *I* striking a thick sheet of plane polished glass is partly reflected at the surfaces and partly transmitted. The light passing through the glass is changed in direction, from that of the incident light. If the surfaces are parallel the transmitted light, on emerging into air is again changed in direction, parallel to that of the incident light. The amount of bending depends upon the difference in the refractive indices of the two media. Part of the light on passing through the glass is reflected from the second surface and so on. The intensities of these reflections however, become negligible because they contain but a small portion of the incident light. When the second surface is silvered the intensity of R_2 will be high. The reflections from the two surfaces account for the double reflected image seen in mirrors and even in clear plate glass.

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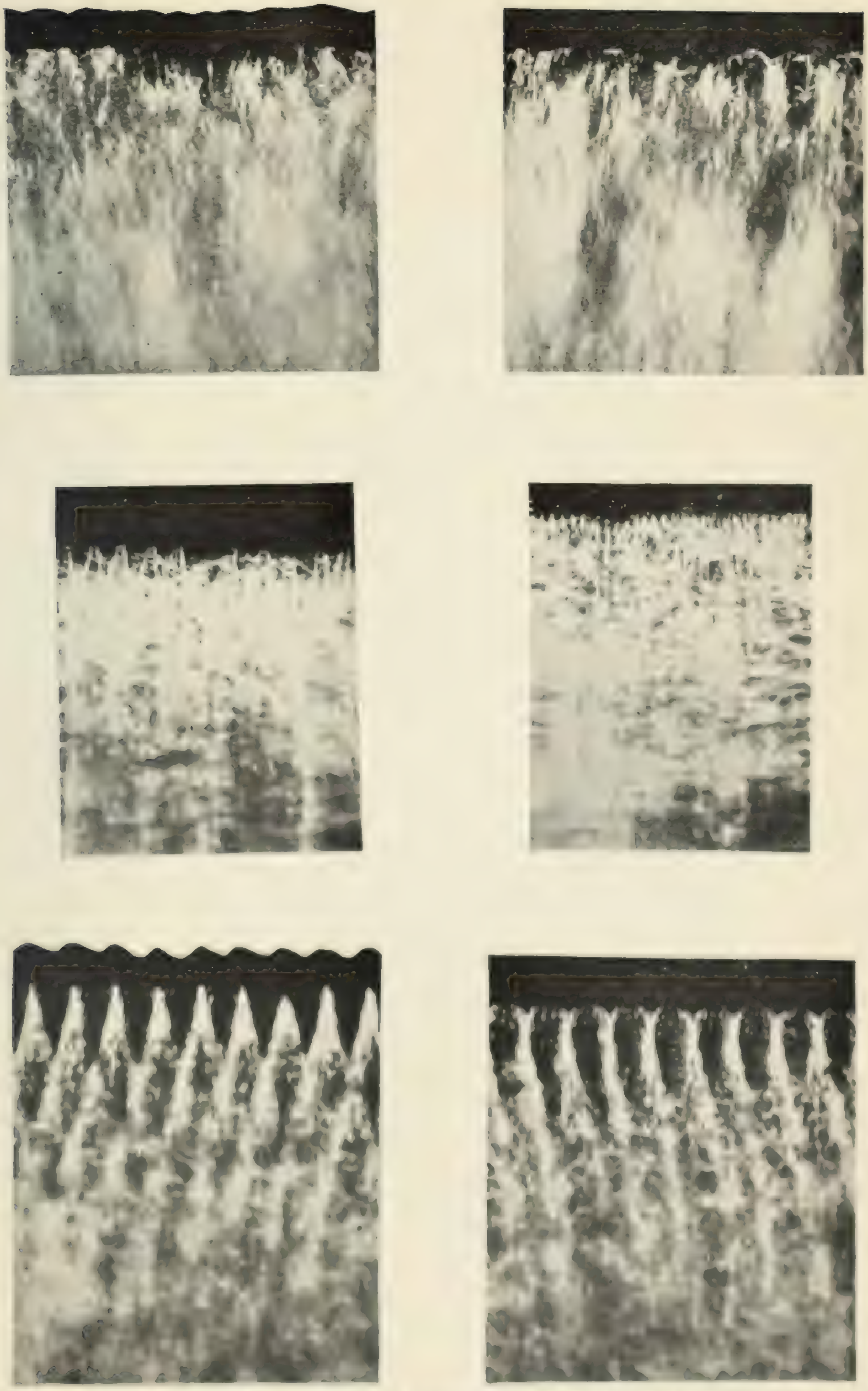


Fig. [illegible].—Showing the scattering of transmitted light by such glasses as pebbled (above), ribbed (middle) and rippled (below).—[illegible] *[illegible]* [illegible], 1918, p. [illegible].

Total Internal Reflection—Light-rays are totally reflected from a "glass-air" surface when the angle of incidence is as great or greater than the angle shown in Figure 22 provided they are in the glass medium just before reaching the surface which is bounded by air.

Refraction and total reflection have been utilized extensively in prismatic glassware with excellent control of the light. Since these principles involve the passage of light through clear glass, the absorption is low, and the efficiency therefore can be of a high order.

TABLE II.—RATINGS OF MEDIA IN RESPECT TO SEVERAL PHASES OF LUMINAIRE DESIGN

	Shading of light-source	Diffusion of light	Redirection of light	Transmitting efficiency	Reflecting efficiency
Crystal glass	—	—	VP	E	VP
Etched or sand-blasted crystal glass	VP	P	P	E	VP
Opal Glass* 1	G	E	F	F	G
Opal Glass* 2	F	G	F	G	F
Opal Glass* 3	P	F	F	E	P
Cased glass	G	E	F	G	G
Enameled glass	F	F	F	F	F
Silvered glass	E		E	—	E
Prism Glass Refracting	VP	—	E	E	—
Prism Glass Reflecting	F	—	E	—	E
Rippled glass	VP	VP	P	E	VP
Porcelain enamel	E	F	F	—	G
Paint enamel	E	F	F	—	G
Polished silver	E	—	E	—	E
Polished aluminum	E	—	G	—	G
Paper (dense)	G	G	F	F	G
Parchment	G	G	F	P	F
Mica (art)	G	P	P	P	P
Textiles (dense)	G	G	F	P	F **
Plaster	E	G	F	—	G

E, excellent; G, good; F, fair; P, poor; VP, very poor.

* Three grades of opal glass are assumed according to their ability to diffuse light; opal glass 1, 2 and 3 having characteristics similar to those illustrated in Figures 10, 11 and 12 respectively.

** For the lighter colors.

With prismatic glass, as with mirrored reflectors and all other types that afford an accurate control of light, it is especially necessary that the light source be in the correct position with respect to the reflector or the desired distribution will not be obtained. In general the light source must be small (approaching

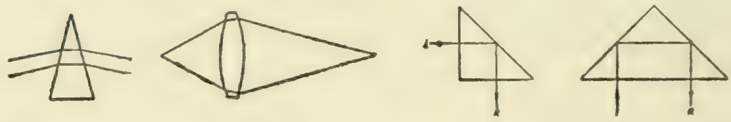


Fig. 20 Fig 21 Fig. 22

Fig. 20.—Refraction of a prism.
Fig. 21.—Refraction of a lens.
Fig. 22.—Total reflection in glass prisms.

the theoretical point-source) if the most accurate control of light is to obtained by refraction and by specular reflection.

In summarizing the characteristics of media for the control of light, specular reflection and refraction afford the most accurate means. Surfaces and transmitting media which scatter light are limited in their control of light although they are very important in the design of many luminaires where highly directed light and exact distributions of light are unnecessary. Figures 23, 24 and 25, will serve to illustrate typical distribution obtainable with these three general classes of media.

As a guide for the proper selection of media for shading, diffusing and redirecting light, some of the more important characteristics of the commonly used media are presented in Table II.

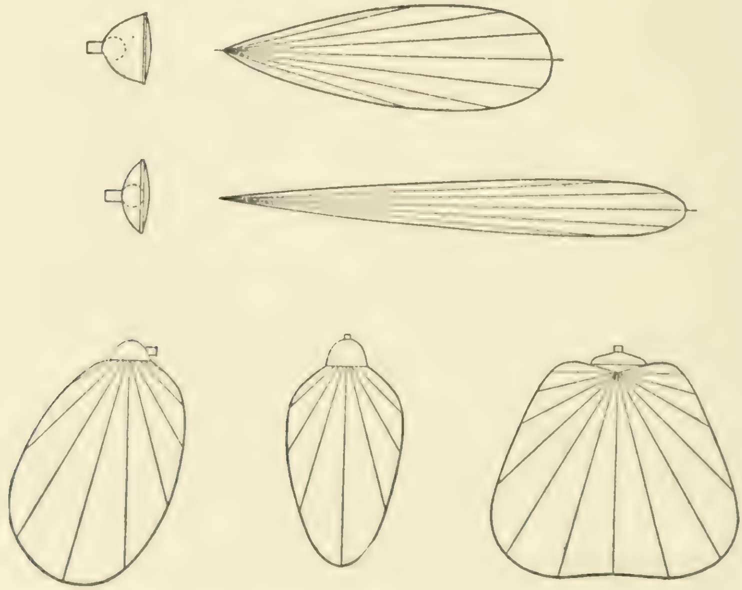


Fig. 23.—Control of light by luminaires employing mirrored surfaces.

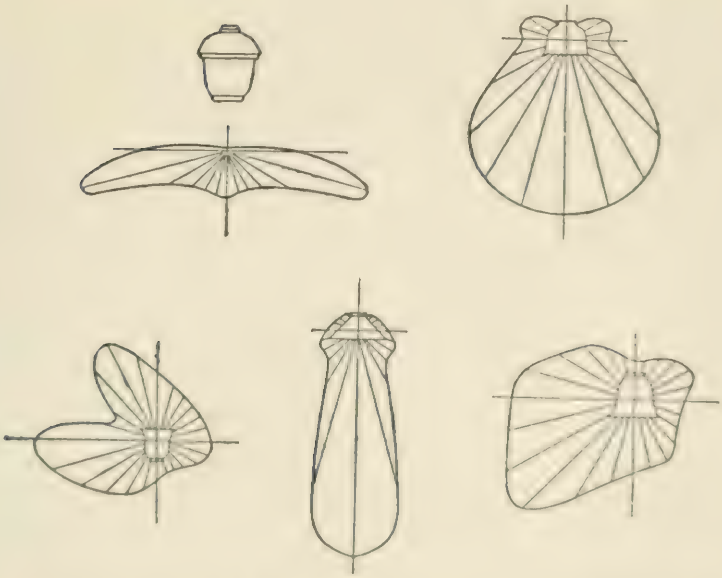


Fig. 24.—Control of light by luminaires employing prism glass.

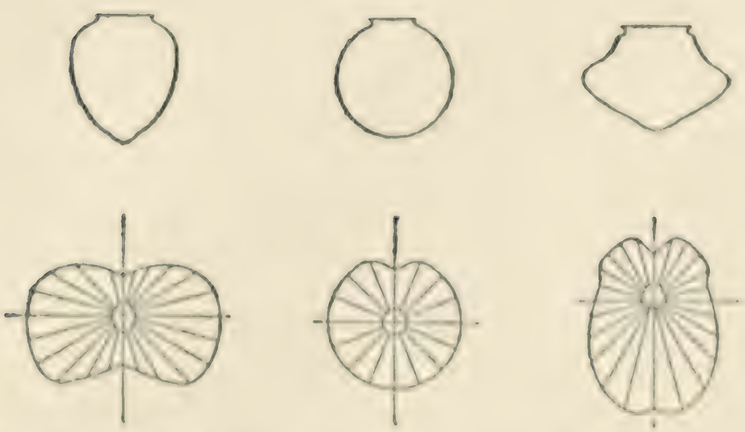


Fig. 25.—Control of light by luminaires employing diffusing glass.

PART III

VARIOUS PHASES OF DESIGN

By properly proportioning the materials usually employed in the design of luminaires it is possible to distribute, to shade, and to control brightness in almost any way desired. As there is no one ideal form of light distribution which solves all the problems to be met, a knowledge of the means of controlling light in those places and quantities desired is of particular importance to the designer.

SECTION 1. LIGHT-DISTRIBUTION OF LUMINAIRES. Luminaires and artificial lighting systems are commonly divided into three broad classes, namely, direct, semi-indirect, and indirect. These classifications are indefinite and only approximate because there are no definite boundaries between the classes and much less distinction between them on the basis of the lighting effects obtained. A light-source equipped with a pendent opaque reflector may be called a direct-lighting luminaire. This same luminaire when inverted falls into the indirect class because the light reaches the working-plane indirectly by reflection from the ceiling, walls, etc. Between these extremes there is an indefinite variety of luminaires and lighting effects.

If the pendent opaque reflector is replaced by an opal-glass shade, the luminaire is still considered a direct-lighting luminaire although the lighting effect is materially altered from that obtained with the opaque reflector. Furthermore when this opal-glass shade is inverted it becomes what is termed a semi-indirect luminaire. With the wide variation in the diffusion of glassware and in the design of luminaires employing diffusely transmitting media, it is possible to have so-called light-density bowls and good diffusing balls producing practically the same lighting effect although the ball would never be called a semi-indirect luminaire or the light-density bowl a direct-lighting luminaire.

A simple diagram such as shown in Figure 26 illustrates all possible combinations of direct and indirect (downward and upward) components of light flux obtained from luminaires. The downward component can be considered as that part of the light emitted by the luminaire in the lower hemisphere and the upward component that portion emitted in the upper hemisphere. The

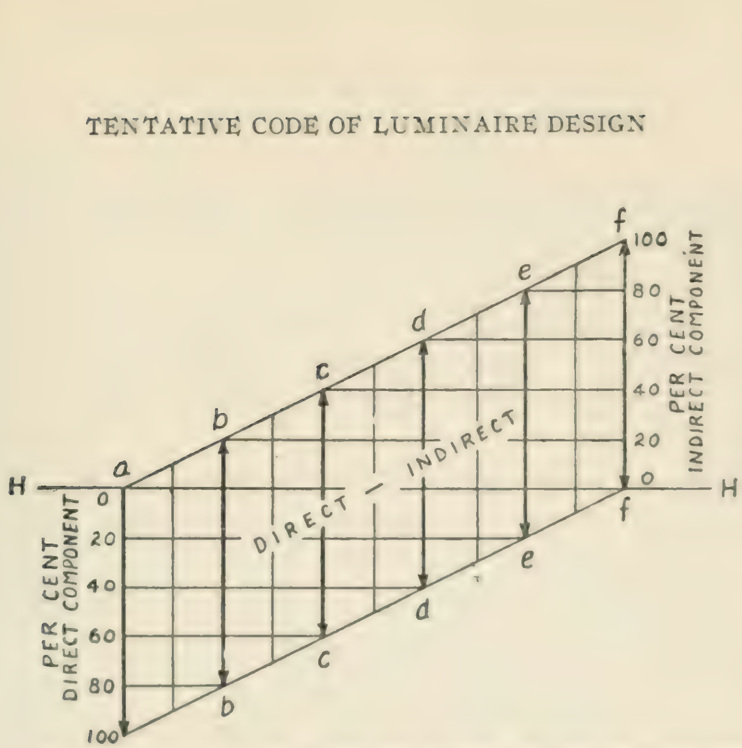


Fig. 26.—Diagrammatic illustration of the distribution characteristics of luminaires in terms of direct and indirect components.

horizontal plane *HH* may be considered to pass through the center of the luminaire which must be considered to be without dimension for the sake of diagrammatic illustration. A luminaire confining all of the light emitted to the lower hemisphere (below the horizontal plane *HH*) would be purely a direct-lighting luminaire. This would be represented at *a*, 100 per cent direct. The luminaire with all the light emitted in the upper hemisphere (100 per cent indirect) would be represented at *f*. Between these extremes is a vast variety of direct indirect lighting.

It is apparent that a more definite idea of the distribution obtained from the vast group between these extremes would result if the term semi-indirect were replaced by the term direct-indirect. A given luminaire would then be specified in such manner as direct-indirect 30-70, signifying that 30 per cent of the light given off by the luminaire was downward and 70 per cent upward. The adoption of this manner of specification would eliminate the confusion and indefiniteness of the term semi-indirect. This rating as implied considers only the light given off by the luminaire and does not enter into the overall efficiency; that is, the designation, direct-indirect 30-70, deals only with the light delivered by the luminaire. For a comparison of the efficiencies of luminaires, the ratio of the light given off by the luminaire to that given off by the light-source would be added. The complete designation for a 30-70 direct-indirect luminaire

with an overall efficiency of 82 per cent would carry this overall efficiency figure. Other factors such as the maximum brightness at various angles and so on could be added to this designation; but since the principle purpose of this classification is to clarify the indefiniteness of terminology these refinements are purposely omitted until a thorough familiarity with the plan has been attained.

SECTION 2. SHAPE AND DISTRIBUTION. Consider three enclosing luminaires of good diffusing glass illustrated in the round ball, the "mushroom" or "squat" type and the "stalacactite" (pendent cone-shaped). While it is true that diffusely transmitting and reflecting media do not offer a means of accurate light-control, a study of the difference in the form of distribution with these three types of enclosing luminaires of diffusing glass will serve to illustrate the possibilities.

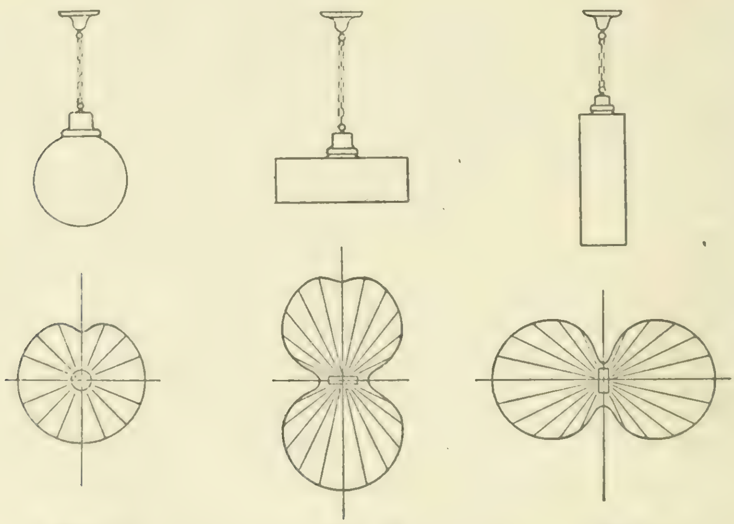


Fig. 27 Fig. 28 Fig. 29

Fig. 27.—Distribution of light by a ball of good diffusing glass.

Fig. 28.—Distribution of light by a flattened or "squat" enclosing luminaire of good diffusing glass.

Fig. 29.—Distribution of light by an elongated or "stalactite" enclosing luminaire of good diffusing glass.

The round ball illustrated in Figure 27 when lighted appears like a round disk of the diameter of the ball regardless of the angle at which it is viewed. Having the same area and brightness when viewed at any angle results in equal amounts of light in all directions.

The "mushroom" type as illustrated in Figure 28 when lighted appears like a flat disk when viewed from above and below and more or less rectangular (according to the design) when viewed from the side. The apparent or projected area in this case is less when viewed from the side than when viewed from above or below; in other words, more or less equal amounts of light are emitted above and below the luminaire and a lesser amount out to the side.

The "stalactite" as illustrated in Figure 29 when viewed horizontally appears as a cylinder or cone. When viewed from above or below it appears as a flat disk of considerably less area than when viewed horizontally. With this shape the large apparent vertical area emits a considerable amount of light horizontally with corresponding lesser amounts above and below.

In each case the amount of light in a given direction is dependent on the apparent or projected area in the given direction, assuming the glass to be illuminated to a reasonable degree of uniformity. The position of the light-source in the enclosing luminaire of good diffusing glass may vary one-half to one inch from the correct position without appreciably altering the distribution of light; however, departures from the correct position which produce brightness considerably in excess of that of other parts of the luminaire should be avoided. The light-source placed close to the bottom of the luminaire will increase the amount of downward light but in so doing high brightness at the bottom of the luminaire may result. On the other hand the source placed close to the top of the luminaire may produce high brightness of the top of the luminaire, a condition ordinarily not harmful as that part of the luminaire is largely out of the field of view. But since this allows a considerable part of the light to pass upward a lesser amount of light is likely to reach the plane to be illuminated when the luminaire is installed.

With direct-lighting open luminaires such as the shade, dome, etc., a greater part of the light is confined inside of a cone. The extent of this cone of light directly from the light-source, may be determined by drawing lines through the source to the edge of the opening of the luminaire. Illustrations of this are shown

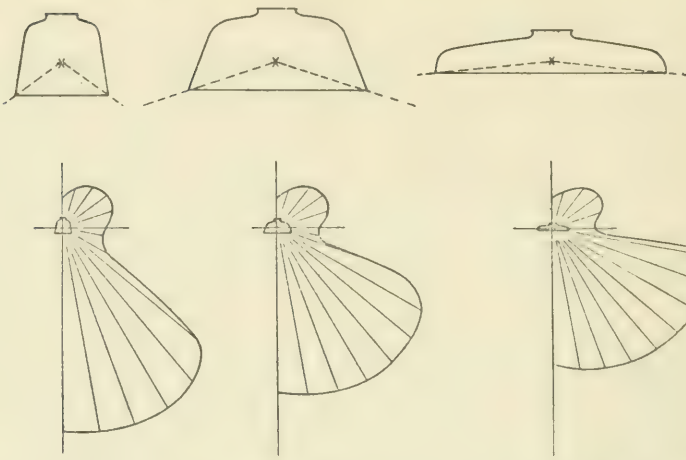


Fig. 30 Fig. 31 Fig. 32

Figs. 30, 31 and 32.—Illustrating the direct cone and respective distributions of light with three shapes of luminaires of dense diffusing material.

in Figures 30, 31, and 32. All of the light is confined to this cone when opaque media are used, while with translucent media as illustrated in Figures 30, 31 and 32, in addition to this direct cone of light there is a certain amount emitted from the diffusing materials of the luminaire according to the transmitting characteristics of the media.

When the interior of luminaire of this type is mirrored or smooth, the distribution of light inside of the direct cone may be somewhat different than that illustrated. In this case use can be made of the regular reflection from the smooth or mirrored surfaces to build up the distribution in certain directions.

SECTION 3. SHAPE AND EFFICIENCY. The efficiency of a luminaire is the ratio of the light given off by the luminaire to the light emitted by the source. One of the most important factors in obtaining efficiency, commensurate with the media selected, is the minimizing of multiple reflections. When light is reflected back and forth a number of times before it is allowed to escape there is said to be multiple reflection. If for example light strikes a medium which reflects 75 per cent of the incident light, 25 per cent will be absorbed on the first reflection, leaving 75 per cent of the original quantity. This part when striking the surface the second time suffers a loss of 25 per cent leaving about 56 per cent of the original quantity. The rate at which this loss accumulates is seen by carrying this to six reflections where only 18 per cent of the original quantity of light remains to escape from the luminaire.

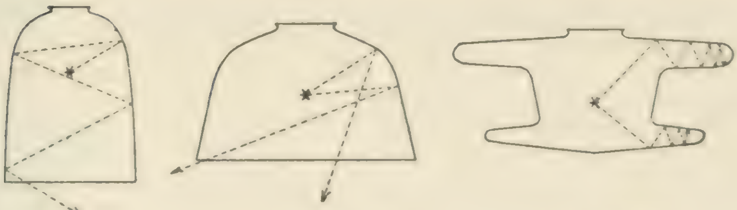


Fig. 33 Fig. 34 Fig. 35

Figs. 33, 34 and 35.—Showing the influence of the shape of the luminaire in producing multiple reflections.

In Figure 33, the path of a ray of light which is reflected several times is shown by the broken line. After the ray of light is reflected several times its intensity is appreciably reduced. In Figure 34 the shape illustrated is comparatively free from multiple reflections. The enclosing luminaire of diffusing glass should have contours which minimize the loss of light by multiple reflections.

The projections shown on the luminaire illustrated in Figure 35 "pockets" the light as indicated by the dotted lines with a resultant lowered efficiency.

SECTION 4. SIZE OF THE LUMINAIRE. In addition to distributing light in the desired direction, a luminaire in order to be satisfactory must not be glaring. Brightness of a given diffusing envelope which is one of the chief factors in producing glare, is readily controlled by varying the area of the diffusing medium and the distance from the light source. For example, the average brightness of a four inch ball of a good diffusing glass, with a 100 watt gas filled lamp, may be 7 candles per square inch while an eight inch ball of this same glass containing the same lamp would have an average brightness of 1.8 candles per square inch. In this case the brightness is dependent on the area and the total amount of light given off by the luminaire.

The brightness of the filament of the 100-watt gas-filled lamp is of the same order of magnitude as the 1,000-watt lamp but the amount of light emitted by the latter is about fifteen times greater than the former. If then a luminaire designed for a 1,000-watt lamp is to have the same brightness as a luminaire for the 100-watt lamp, the area of the former must be greater in proportion to the amount of light emitted by the source, when the same medium is used.

TABLE III.—BRIGHTNESS AND SIZE OF ENCLOSING GLOBES OF GOOD DIFFUSING GLASS *.

Source	Diameter of globe (inches)	Brightness ** (average candles per sq. in. of surface)
100-watt lamp (gas-filled)	5	4.5
100-watt lamp (gas-filled)	6	3.1
100-watt lamp (gas-filled)	7	2.3
100-watt lamp (gas-filled)	8	1.8
100-watt lamp (gas-filled)	9	1.4
100-watt lamp (gas-filled)	10	1.1
100-watt lamp (gas-filled)	12	0.8
100-watt lamp (gas-filled)	14	0.6
Sky	—	2.0

* The globes are assumed to be fairly uniform in brightness and to have an overall efficiency of 85 per cent.

** A lambert is 2.054 candles per square inch.

The effectiveness of controlling brightness by varying the size of the luminaire is shown in Table III. These values obtain with enclosing globes of good diffusing glass with the light-source located so that the brightness is fairly uniform. The globes are of such character as to emit 85 per cent of the total output of light from the lamp. For the sake of comparison the average brightness of the sky is included.

Aside from the size of the luminaire the diffusing qualities of the medium chosen are of great importance. A 12-inch enclosing globe can be obtained which, while it diffuses the light, when illuminated with a 100-watt gas-filled lamp, will have a spot of brightness considerably higher than the rest of the globe. The brightness of this spot may be of the order of 20 candles per square inch as against 0.8 candle per square inch for the good diffusing glass.

The brightness of this spot can be reduced to that comparable with the good diffusing glass by increasing the size of the globe, however the size of globe necessary to accomplish this would be such as to make this means of reducing the maximum brightness of the luminaire impractical.

TABLE IV.—RECOMMENDED GLOBE SIZES OF HIGH EFFICIENCY, GOOD DIFFUSING GLASS WHEN USED UNSHIELDED*

Lamp size (watts)	Globe diameter (inches)	Brightness** of brightest square inch (approximate candles per sq. in)
50– 75	8	2.5
75–100	10	2.5
100–150	12	3.0
150–200	14	3.5
200–300	16	4.0
300–500	18	5.0

* The globes are assumed to be substantially uniform in brightness.
** Values that obtain with the larger size of lamps.

Definite values for the allowable brightness of luminaires depend on the hanging-height, angle at which the luminaire is likely to be viewed, the kind of interior, the reflection-factors of the surroundings such as walls and ceiling, the use for which the interior is intended, etc. Any specific recommendations must take these factors into account.

As an average value which may be considered to provide for average conditions three candles per square inch may be taken. This value would probably be higher than that desirable in some interiors and on the other hand there are other conditions where this value could be exceeded. If however a value of this order is used as a limiting value satisfactory results will obtain in most cases.

The values in Table IV are included as a guide in the proper selection of size for the enclosing luminaire of good diffusing glass. Furthermore the brightness obtained with the globe and lamp sizes used in the table may serve as a working standard in the design of other luminaires. The higher brightness values shown in the tables for the larger sizes of lamps are allowed, for these larger luminaires are generally suspended higher than the smaller ones. At these higher hanging heights luminaires are less in the line of vision.

It may be of interest to compare the brightness of various light sources presented in Table V with each other and also with the values in Tables III and IV.

TABLE V.—BRIGHTNESS OF VARIOUS LIGHT SOURCES

Source	Brightness (Candles) (per sq. in.)	Authority
Kerosene flame	9	Ives and Luckiesh
Gas flame (fish tail burner)	2.7	Ives and Luckiesh
Welsbach mantel	31	Ives and Luckiesh
Acetylene flame (1 ft. burner)	53	Ives and Luckiesh
Cooper Hewitt mercury-vapor lamp	14.9	Ives and Luckiesh
Crater, open carbon arc	84,000	Ives and Luckiesh
Carbon filament (2.5 l. p. w.)	325	Ives and Luckiesh
Graphitized carbon filament (4 l. p. w.)	750	Ives and Luckiesh
Tantalum filament (5 l. p. w.)	580	Ives and Luckiesh
Tungsten filament (vacuum lamp) (8 l. p. w.)	1,060	Ives and Luckiesh
Tungsten filament 50-watt (gas-filled)	2,630	Forsythe
Tungsten filament 500-watt (gas-filled)	4,500	Forsythe
50-Watt opal-glass bulb (gas-filled)	8.3	Forsythe
75-Watt white-coated bulb (gas-filled)	13.5	Forsythe
Enameled portion (bowl-enameled lamps)	10—15	—

SECTION 5. LIGHT-SOURCES. The previous paragraphs in dealing with the principles of light-control, have in many ways involved the amount of light emitted by the source, the size of the source, the position of the light-source with respect to the contact-point of the base and so on.

TABLE VI.—INCANDESCENT GAS MANTLES

Type	Number of mantles	Gas * pressure (inches)	Gas** consumption (cu. ft.)	Light output (lumens)	Dimensions	
					Length (inches)	Diameter (inches)
Large inverted mantle	1	2.5	7.59	1977.9	2½	1¾
Standard inverted mantle	1	2.5	4.78	1285.5	1¾	1⅜
Medium inverted mantle	1	2.5	2.64	736.4	1⅜	1 3/16
Small inverted mantle	1	2.5	1.89	619.5	1⅛	⅞
Small inverted mantle Cluster unit	3	2.5	3.35	996.5	15/16	⅝
Standard upright mantle unit	1	2.5	4.83	1480.3	3⅝	1 1/16
Small upright jr. mantle unit	1	2.5	2.33	551.6	2½	11/16
Small thrift upright mantle unit	1	3	2.6	375	13/16	13/16
Small twin thrift upright mantle unit	2	3	5	813.5	13/16	13/16

Authority—Laboratories of Welsbach Co.

* Gas pressure measured in inches of water column.

** Artificial low pressure gas.

When distributing light by reflection and refraction an accurate control is afforded and in turn the position of the light-source must be confined to narrow limits. In the case of diffusely reflected and transmitted light a less accurate control of light is afforded and in turn the position of the light-source need not be confined to these same limits. Inasmuch as a large part of the design of the luminaire is dependent on the light-source, some of the more important data pertaining to the light-sources are incorporated in Tables VI to IX and in the contour drawings shown in Figures 36 to 40. The data presented in these tables and drawings, while correct at the time of writing, are subject to change.

TABLE VII.—MULTIPLE VACUUM TUNGSTEN LAMPS

Volts	Watts	Total lumens	Type	Bulb diameter (inches)	Max. overall Length (inches)	Screw base
			Straight side			
110, 115 and 120	10	80	S-17	2 1/8	5 1/16	Medium
	15	129	S-17	2 1/8	5 1/16	Medium
	25	240	S-17	2 1/8	5 1/16	Medium
	40	404	S-19	2 3/8	5 9/16	Medium
	50	510	S-19	2 3/8	5 9/16	Medium
	60	612	S-21	2 5/8	5 11/16	Medium
			Round bulb—all frosted			
110, 115 and 120	15	113*	G-18½	2 5/16	3 15/16	Medium
	25	204*	G-18½	2 5/16	3 15/16	Medium
	25	225*	G-25	3 1/8	4 13/16	Medium
	40	371*	G-25	3 1/8	4 13/16	Medium
			Mill type			
110, 115 and 120	25	203	P-19	2 3/8	3 11/16	Medium
	50	420	P-19	2 3/8	3 13/16	Medium
			Tubular bulb			
110, 115 and 120	25	238	T-10	1 1/4	6	Medium
	40	348	T-8	1	12 1/4	Medium
			Decorative lamps—all frosted			
110, 115 and 120	15	100*	B-9½	1 3/16	3 5/8	Candelabra
	15	100*	G-16½	2 1/16	3 1/8	Candelabra
			Country home lighting			
28-32	10	94	S-17	2 1/8	5 1/16	Medium
	20	196	G-18½	2 5/16	3 15/16	Medium
	25	265	S-17	2 1/8	5 1/16	Medium
	40	424	S-19	2 3/8	5 9/16	Medium

* Approximate value.

TABLE VIII.—MULTIPLE GAS-FILLED LAMPS

Volts	Watts	Total Lumens	Type	Bulb diameter (inches)	Max. overall length (inches)	Screw base	Light-center length inches
110, 115 and 120	50	450**	PS-20*	2½	5 3/16	Medium	—
	75	880	PS-22	2¾	6 3/16	Medium	4 5/16
	75	780**	PS-22***	2¾	6 3/16	Medium	—
	100	1300	PS-25	3⅛	7¼	Medium	5 3/16
	150	2100	PS-25	3⅛	7¼	Medium	5 3/16
	200	3000	PS-30	3¾	8 7/16	Medium	6
	300	4900	PS-35	4⅜	9 15/16	Mogul	7
	500	9000	PS-40	5	10 5/16	Mogul	7
	750	14000	PS-52	6½	13 9/16	Mogul	9½
	1000	20000	PS-52	6½	13 9/16	Mogul	9½
Country Home Service							
28-32	50	640**	PS-20*	2½	5 3/16	Medium	—
	50	740	PS-20	2½	5 9/16	Medium	3¾
	75	1215	PS-22	2¾	6 3/16	Medium	4 5/16
	100	1700	PS-25	3⅛	7¼	Medium	5 3/16

* Opal glass bulb.
** Approximate value.
*** White-coated bulb.

TABLE IX.—DAYLIGHT GAS-FILLED LAMPS

Volts	Watts	Total lumens*	Type	Bulb diameter (inches)	Max. over-all length (inches)	Screw base	Light center length (inches)
110,115 and 120	75	600	PS-22	2¾	6 3/16	Medium	4 5/16
	100	900	PS-25	3⅛	7¼	Medium	5 3/16
	150	1400	PS-25	3⅛	7¼	Medium	5 3/16
	200	2100	PS-30	3¾	8 7/16	Medium	6
	300	3400	PS-35	4⅜	9 15/16	Mogul	7
	500	5800	PS-40	5	10 5/16	Mogul	7

* Approximate value.

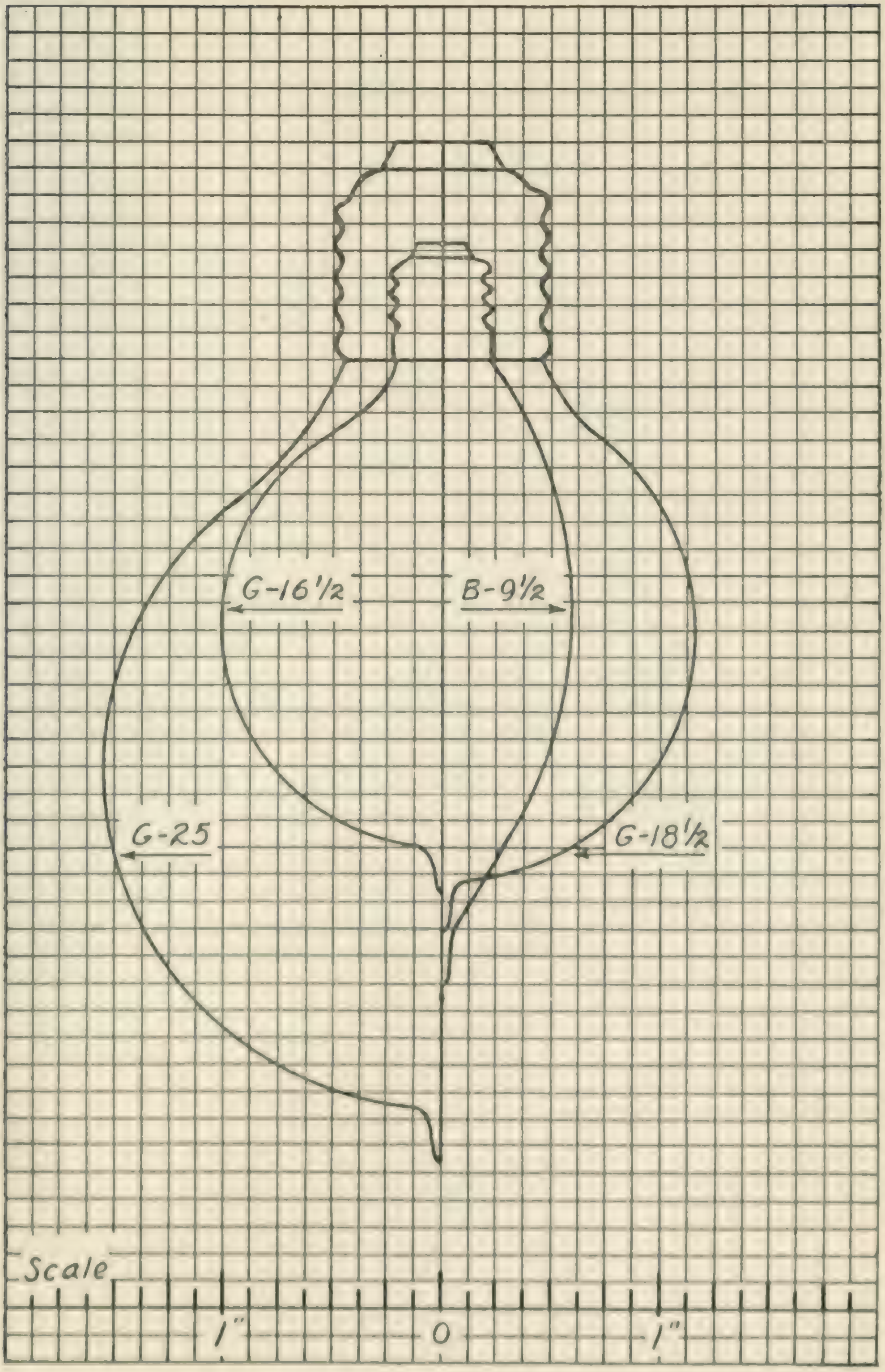


Fig. 16.—Bulb contours of incandescent filament lamps

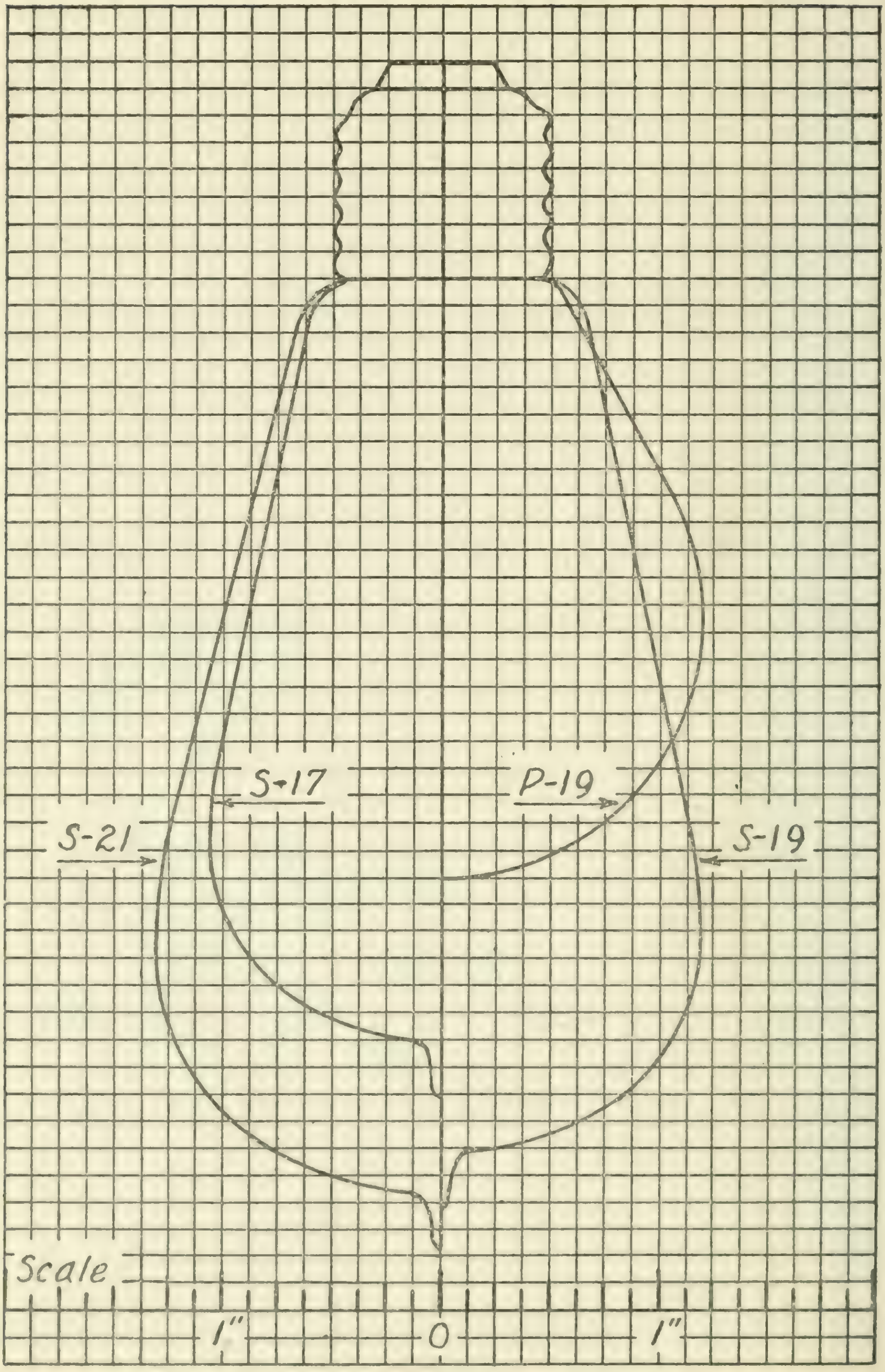


Fig. 37.—Bulb contours of incandescent filament lamps.

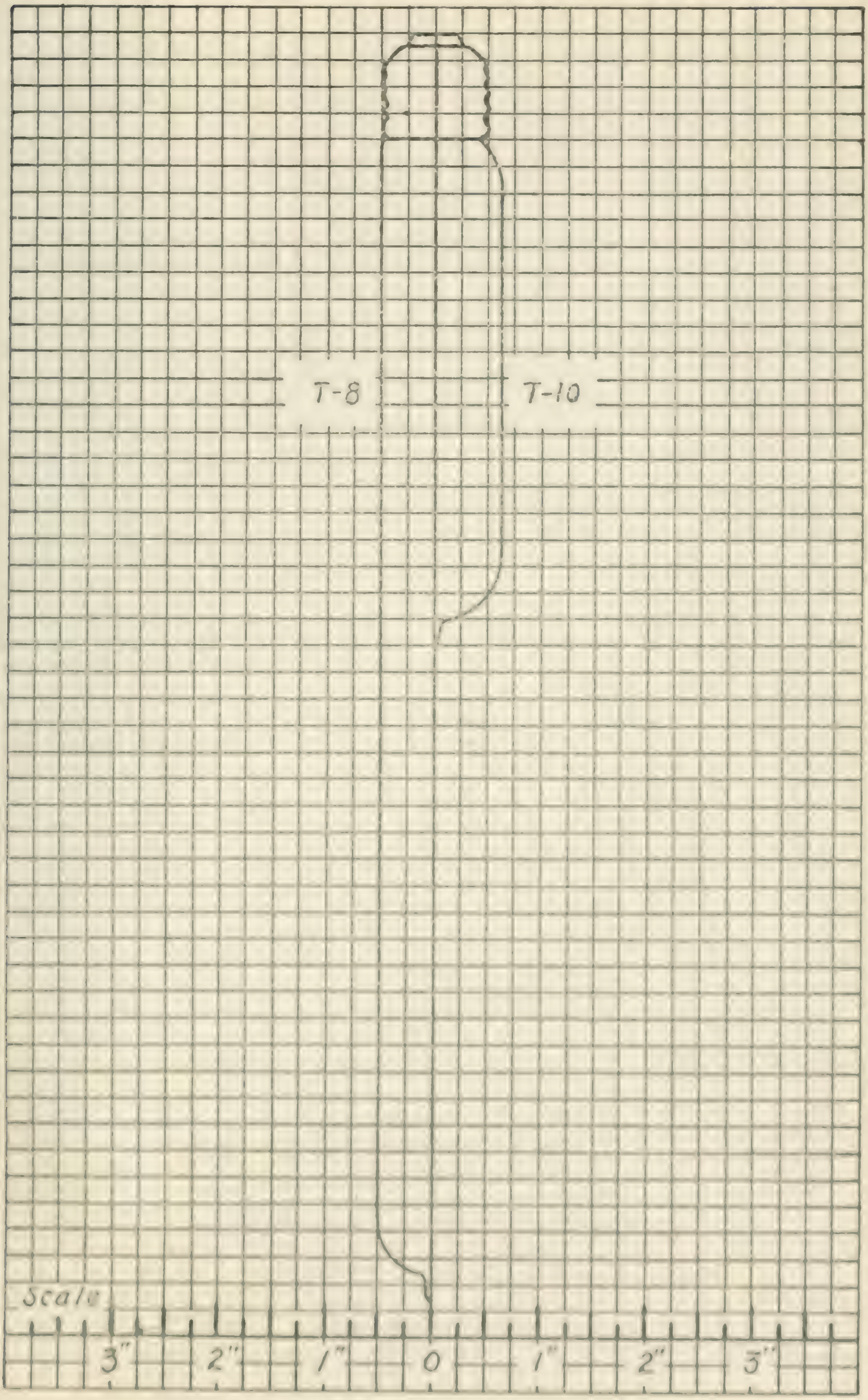


Fig. 18.—Bulb contours of incandescent filament lamps

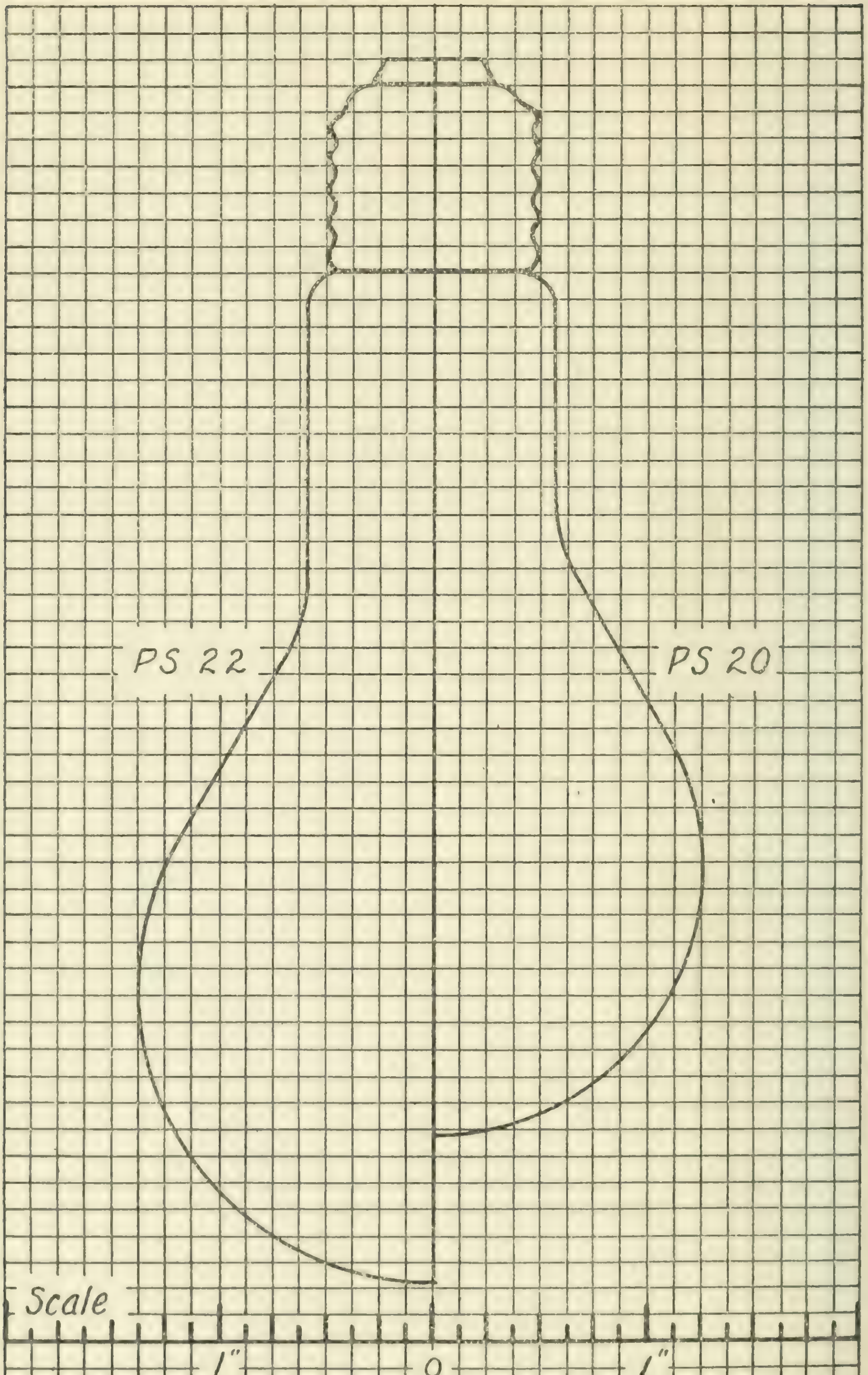


Fig. 39.—Bulb contours of incandescent filament lamps.

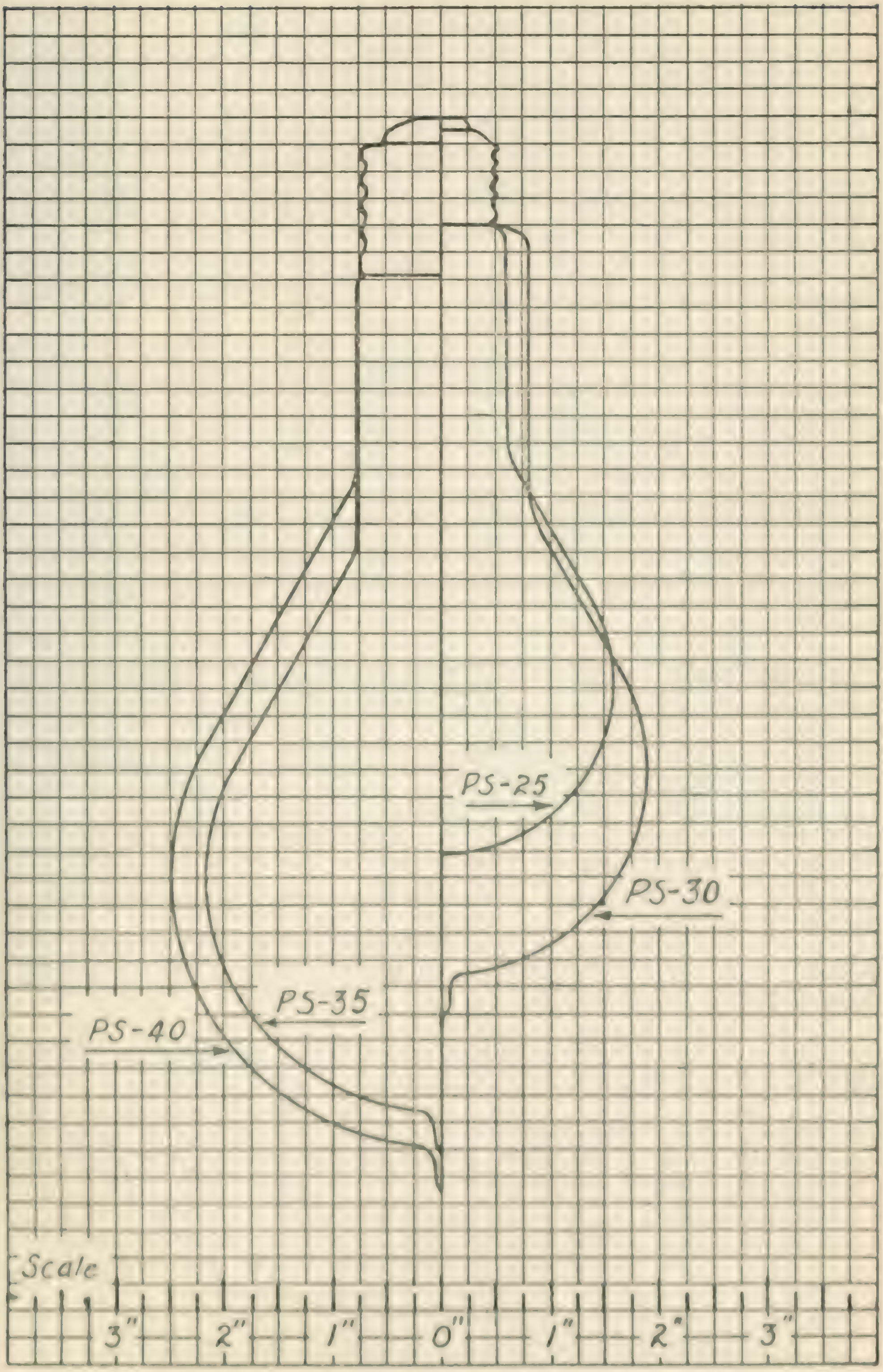


Fig. 40.—Bulb contours of incandescent filament lamps.

PART IV

VENTILATION AND RADIATION

Most of the early rulings stated that ventilation was necessary in order to reduce the temperature of the exposed surfaces of the luminaire and at the same time to prevent decreasing the life of electric filament lamps. There is no doubt that ventilation usually cools the lamp-bulb and some parts of the luminaire to a certain extent, but this is ordinarily accomplished by a corresponding temperature rise in other parts.

Ventilation accomplished by holes in the bottom or top of the luminaire frequently causes the electric wire and socket to be raised in temperature owing to the circulation of heated air against these parts. Inasmuch as one of the most important considerations, from the standpoint of the National Electric Code, is the temperature of the wire where it is connected to the lamp-socket, ventilation may in cases of this kind defeat its purpose.

The impression that the life of an incandescent filament lamp is appreciably shortened by high surrounding temperature has also led designers to ventilate luminaires in various ways. The range of filament temperature for regular gas-filled lamps is approximately from 4,000° F. to 5,000° F. so that the effect of the temperatures of air usually found in luminaires is so small as to be unnoticeable even in carefully conducted life-tests. In those exceptional cases where the surrounding temperatures are excessively high the lamp will generally show a blistered bulb, loose base, melted solder and so on before any serious effect is shown upon the filament.

The ordinary hot-water radiator utilizes the principle of radiation to carry off its heat to the air in the room. The radiator in this case is of sufficient area to heat the room without being excessively hot itself and at the same time a large amount of heat is furnished to the room by the radiator. In a similar way the luminaire of adequate size will dissipate the heat given off by the light-source without becoming excessively hot. The advantages to be obtained by utilizing radiation as a means of cooling are (1) a more uniform temperature of the luminaire; (2) in many cases a lower temperature of socket and wire than obtained

by ventilating holes; (3) considerably less depreciation due to the lessened dust collection on the inside of luminaire and on the lamp bulb; (4) the elimination of ventilating holes which may be undesirable from the standpoint of appearance. That satisfactory cooling of luminaires can be effected by radiation has been proved by many non-ventilated luminaires which are now in service.

Such materials as silk, paper and parchment should not be located too near the light-source in order to prevent deterioration and to eliminate fire-hazard.

PART V

MAINTENANCE

Maintenance has been considered primarily a function to be performed by the owner of lighting equipment; however, if cleaning is given proper consideration during the design of the luminaire, the cost of maintenance can be reduced to a minimum. The luminaire when new and first installed should deliver and direct light in the quantity and direction for which it was designed. To assure sustained performance over a period of time, the luminaire should be designed with maintenance in mind. A comparison of the losses due to dust and dirt, found with the open bowl and the same bowl closed with a clear glass cover, as illustrated in Figures 41 and 42 respectively, will serve as an example of loss of light due to the accumulation of dust.

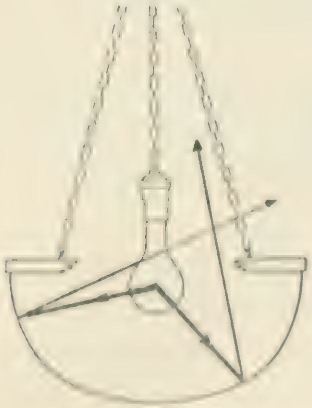


Fig. 41

Fig. 42

Fig. 41.—Illustrating the losses of light due to dust on various parts of the open bowl luminaire.

Fig. 42.—Illustrating the losses of light due to dust with the enclosed bowl with clear-glass top.

The losses due to the dust with the open bowl may be analyzed as follows:

(1.) Light leaving the filament suffers loss upon passing through the dust layer on the bulb.

(2.) A considerable part of the light leaving the bulb strikes the bowl which is dust covered; in passing through this layer to the bowl there is a loss.

(3.) That part which has gone through the dust layer is reflected back and passes again through this same layer with resultant loss.

(4.) Some of the light reflected from the interior of the bowl passes through the dust covered lamp bulb before leaving the luminaire and further losses follow, both on entering the bulb and on leaving it.

In comparison with these losses take the same bowl, enclosed with a clear glass top so as not to appreciably alter the distribution of light. With this condition the losses may be analyzed as follows:

(1.) Light from the source that passes through the bulb to the bowl is reflected to the glass top with no appreciable loss due to dust. In passing through the clear glass top there is the single loss due to dust collection on the outside surface of this cover. In both cases there is a loss of the same order of magnitude due to the dust collection on the outside of the bottom of the bowl when transmitting media are used.

In addition to the normal collection of dust on the exposed surface of a luminaire there is the agitation of dust particles carried by the air when the luminaire is heated by the light-source.

This action is similar to that found around a radiator. The heated radiator causes the cold air surrounding it to be raised in temperature and this heated air rises allowing the cooler air from below to pass through this same cycle. The heated luminaire produces a similar effect on the surrounding air. The effect of the shape of the luminaire upon air-currents and dust-accumulation is worthy of attention. Figures 43 and 44 illustrate approximately the currents of air in and around luminaires.

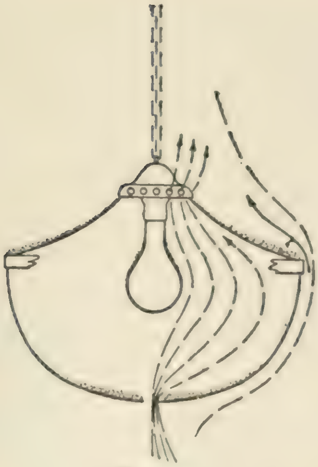


Fig. 43

Fig. 44

Figs. 43 and 44.—Illustrating the circulation of air in and around the enclosed luminaire with and without holes respectively.

When the luminaire itself has openings in it, such as holes in the bottom, in the holder, or a combination of both, the heated air in the luminaire rises rapidly through the holes at the top with an inrush of dust laden cooler air through the bottom openings. This results in a coating of dust over the interior of the luminaire and lamp-bulb which would not be present if the holes did not exist. If then a luminaire is purposely designed to surround the light-source so as to reduce losses from dust accumulation a considerable part of its effectiveness is destroyed when openings of this kind are added.

Even the enclosing luminaire with a single bottom opening and no top opening generally shows a more rapid rate of depreciation than would be found if the hole were stopped. This is due to the "breathing" of the luminaire. When the luminaire is lighted some of the expanded air passes out through the opening, this in turn is followed by some of the dust-laden air being drawn through this opening into the luminaire when the light-sources are extinguished. As this cycle repeats itself each time the luminaire heats and cools a considerable amount of dust may enter through a single opening.

Aside from these losses due to dust collection, deterioration of surfaces, such as the tarnish of silver, the yellowing of some white paints, and so on, may result in further losses. In fact a gradual deterioration takes place with some material which ultimately

results in the loss of the greater part of the light that is controlled by the luminaire. In Table X the permanency, ease of cleaning and other factors that enter into depreciation are shown for the media commonly used in luminaires.

TABLE X.—MAINTENANCE FACTORS OF COMMONLY USED MEDIA

Material	Deterioration *	Restoration	Ease of cleaning
Crystal glass	None	Excellent	Excellent
Etched glass	None	Good	Fair
Opal glass	None	Excellent	Excellent
Enamel glass (fired)	None	Excellent	Excellent
Silvered glass	Very slight	Excellent	Excellent
Prism glass	None	Excellent	Fair
Rippled glass	None	Excellent	Fair
Paper	Gradual	Poor	Poor
Parchment	Gradual	Fair	Fair
Mica (art)	None	Excellent	Excellent
Textiles	Gradual	Fair	Poor
Porcelain enamel	None	Excellent	Excellent
Painted surface (matt)	Gradual	Fair	Fair
Painted surface (glossy)	Gradual	Good	Good
Polished silver	Rapid	Fair	Fair
Polished aluminum	Gradual	Fair	Fair
Plaster	Gradual	Good	Fair
Enamel glass (unfired)	Gradual	Good	Excellent

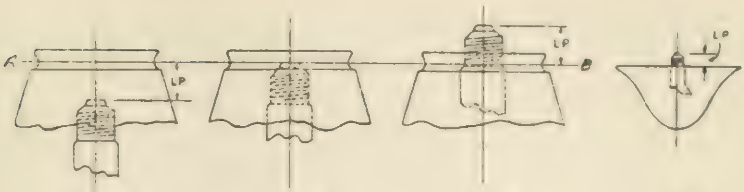
*Normal interior atmospheric conditions are assumed. Of course all materials will suffer deterioration under extreme conditions.

PART VI

HOLDERS, HUSKS AND HEELS

There are many mechanical and electrical features involved in the design of a luminaire with which some designers have given due consideration, while others have neglected this responsibility. As this phase of the design of luminaire data does not appear to be properly within the scope of this Code, only those mechanical features which have to do with lighting results will be dealt with.

For practical purposes it may be said that there is a definite position or a range of positions for the light-source with a given luminaire if the results for which the luminaire was designed are to be obtained. To co-ordinate the efforts of the designer, the testing laboratories, the merchandiser and those responsible for installing luminaires two definite reference points should be adopted one of which is the base cantact-point of the incandescent filament lamp, and the other is the plane drawn through the minimum diameter of the heel. The latter is shown as line *AB*



LP=+1"	LP=0	LP=-1"	LP=-1"

Fig. 45	Fig. 46	Fig. 47	Fig. 48

Figs. 45, 46, 47 and 48.—Illustrating various distances of the base-contact of lamp from the plane of minimum diameter of heel. These different distances are represented by different values of LP. Fig. 48 represents the case of a luminaire (a bowl) without a heel.

in Figures 45 to 47. It is a plane passed through the points of contact of the holder-screws when such are used. No standard symbol is in use to designate the dimension or perpendicular distance between the base contact and the plane of minimum diameter of heel. The symbol, *LP*, (implying lamp-position) is used herewith. For example, this dimension or distance in Figure 45 is LP = + 1. In other words one inch must be added to the distance of the center of the lamp filament from the base-contact in order to obtain the distance of the center of the light-source from the plane of the heel. In Figure 46, LP = 0. In Figure 47, LP = − 1 inch, the negative sign indicating that the distance from the center of the filament to the plane of the heel is one inch less than to the base-contact of the lamp. The light-center length, or distance from base contact to center of filament can be obtained from preceding tables.

Various points of reference have been used heretofore for locating the light-source with respect to the luminaire. The most commonly used reference points are the top edge of the heel and the base contact of the lamp. This however is open to serious objection due to the variation in the height of the heel and also in the variation in the grinding off of the heel. In selecting the minimum diameter of heel (the point of contact for holder screws) the variables likely to be encountered with other points of reference are somewhat reduced.

For the exceptions where there is no heel, Figure 48, the plane of the top of the edge of the glassware, reflector, etc., and the base-contact point of the filament lamp would be the reference points and their distance apart would be designated by *LP*.

At present there are a large number of holders, some with lamp receptacles and others to be attached to the receptacles; in addition there are husks to which reflectors and shades may be attached. All of these devices are for holding reflectors and shades and therefore play an important part in establishing definite positions of the light-source with respect to the shade or reflector. A given reflector may be used with a holder, detachable holder or husk of the same general size and in each case the light-source may be in a different position. To assure uniform results with these various types of holders and husks of a given size, a set of standard dimensions indicating the distance *LP* between the base-contact of the lamp and the plane of the holder screws should be adopted. Four values of *LP*, + 1 inch, 0, −1 inch, and −2 inch, are largely in use at present so that no great confusion would arise in their standardization and at the same time they will be found to meet a large percentage of the requirements. This standardization is independent of the diameter of heel accomodated as it is intended that any size of these lamp positions can be incorporated with any of the heel sizes in use. For example, the holders and husks for the 3¼-inch heel would be available with the four values of *LP;* that is, four different distances between the base contact point of the lamp and the center line of support. Using the suggested symbol *LP* for this dimension, a typical holder would be termed 3¼-inch holder with an *LP* dimension of + 1 inch.

At the present time there are holders coming into use which are constructed so as to provide the correct position of the light-source for more than one size of lamp, this being effected in most cases by placing the lamp receptacle in different positions. To insure that they be properly used the socket positions and the corresponding lamp sizes should be clearly marked.

In some of the preceding sections of the Code the means of affording a control of the brightness has been dealt with. These general points of design are the fundamentals to be followed to obtain satisfactory results. The designer and manufacturer however are generally at the mercy of the ones responsible for installing luminaires. For example, an enclosing luminaire of adequate size to provide low brightness with a 100-watt lamp is likely to be large enough for 200-watt lamp. In equipping

this luminaire with the lamp of larger size, a brightness will result which may render it unsatisfactory.

The size of the heel selected for enclosing luminaires offers a means in many cases of preventing the use of lamps larger than that designed for. If an enclosing luminaire for 100- and 150-watt lamp is designed with a four-inch heel, it is obvious that a larger size of lamp cannot be used. The recommended sizes of heel for the various sizes of lamps are given in Table XI.

TABLE XI.—RECOMMENDED HEEL SIZES FOR THE RESPECTIVE LAMP SIZES

Nominal heel size (inches)	Lamp size gas-filled (watts)
3¼	75
4	100- 150
5	200
6	300- 500
8	750-1000

The overall length of the enclosing luminaire may also be designed to prevent the use of lamps larger than those for which it has been designed. As a high brightness may result at the bottom of the luminaire when the light-source is placed too close to the bottom, the depth of the luminaire should receive due consideration.

The danger of falling glassware should be borne in mind and adequate means for its prevention should be provided. Even the smaller pieces of glass hung comparatively low may cause injury of no small consequence.

Set-screws are sometimes loosened by vibration or other causes, allowing a part of the luminaire to fall. Some consumers are demanding a locking device for set-screws. Whenever feasible such a safety feature should be employed.

Socket extensions are often used in such a manner as to defeat good lighting. If for any reason, such as an imperative change in the size or design of the incandescent lamp, the socket-extension must be used, its dimensions should be such as to locate the light-source in the proper position in the luminaire.

The medium-to-medium socket-extension is made at the present time with a difference between contact-points of about 1⅜ inches, whereas the difference in light-center length between the 75-watt and the 100-watt (also 150-watt) lamp is about seven-eight inch. The difference in light-center length of the 100-watt (also 150-watt) and the 200-watt lamp is about seven-eight inch. When this adapter is used with a 75-watt lamp in what would regularly be a 100- or 150-watt luminaire, the filament of the 75-watt would be one-half inch from the correct position. The results obtained with enclosing globes of good diffusing glassware would not be materially altered by this change; however, with most open luminaires, such as reflectors and bowls, the distribution may be materially altered and what is even more serious, a part of all of the source may become visible thus causing glare. The desirability of making medium-to-medium extensions with a seven-eight inch difference between the contact-points is therefore obvious.

The mogul medium adapter may be used with the 200-watt lamp in these luminaires designed for the 300- and 500-watt lamp. The adapter to be correct should have a difference of one inch between the contact-points. Some manufacturers are now furnishing this with the correct dimensions.

The mogul-to-mogul socket-extension can be used with 300- and 500-watt lamp in those luminaires designed for the 750- and 1,000-watt lamp. The difference between the contact-points of this adapter should be 2½ inches.

PART VII

DEFINITIONS

The confusion which exists among the manufacturer, designer, dealer, and the public as to the names and what constitutes the different luminaires makes it desirable to standardize terms and descriptions for the luminaires commonly used.

Luminaires supported by the ceiling may be divided into two classes, those fitted close to the ceiling are to be termed ceiling-type luminaires while the remainder, using chains, tubular or solid stems, cords and the like are termed suspension-type.

Bowl—A bowl-shaped luminaire used to produce so-called semi-indirect or totally indirect lighting. Usually a predominant component of light is emitted upward.

Shower—A luminaire consisting of two or more lamps hung in a downward position.

Rosette—A luminaire fitting close to the ceiling consisting of one or more rosettes each containing a socket.

Candelabra—A luminaire consisting of a number of light-sources mounted as upright imitation candles.

Dome—A luminaire consisting of large shade with a wide opening at the bottom directing all or a large part of the light downward. This luminaire can be considered as the reverse of the bowl.

The intent of the definition is to classify this luminaire as one of large dimensions to be used primarily in the dining room.

Bowl and Shower—A luminaire which is a combination of the bowl and the shower.

Enclosing globe—A luminaire, the material of which regardless of shape, entirely envelopes the light-source.

Drop Cord—A luminaire consisting of a cord suspended from the ceiling with one socket attached.

Bracket—A luminaire fastened to the wall or to an article of furnishing.

Portable—A luminaire such as the floor lamp and table lamp which is readily moved without need for fastening it to other objects.

Convenience outlet—A finished outlet in the wall, baseboard, floor, article of furnishing, etc., to which portables and appliances may be easily attached.

Respectfully submitted,

COMMITTEE TO CO-OPERATE WITH FIXTURE MANUFACTURERS.

M. LUCKIESH, *Chairman*
E. W. COMMERY, *Secretary*

W. T. BLACKWELL
S. G. HIBBEN
R. H. MAURER
W. F. MINOR
A. L. POWELL
SAMUEL SNYDER

DISCUSSION

W. H. Rolinson: I have been very much interested in this report. I think the Committee have done a very valuable piece of work. Actually, lighting fixtures are sold in many cities by manufacturers whose standards of quality are very unsatisfactory from a lighting standpoint. Many of these lighting fixtures have wires of insufficient size, the attachment of the wires to the sockets is done carelessly, the lighting center lengths for the lamp is in many instances improper and the mechanical features of the fixture which have to do with the character of the service are so poor that in many instances not only does improper lighting result but no light at all is available because of the failure in these particulars.

I believe these statements are particularly true as regards residencial lighting fixtures. In most of the apartments in which I have lived in New York City, I think that in most cases I have found one or more fixtures in which some of the sockets were inoperative or mostly so. I would like to suggest, therefore, that this Committee concern themselves with the mechanical features of lighting fixtures particularly as to the character of sockets, the attachment of wires and size of wires and other things of this character which are really important from a lighting standpoint.

N. D. Macdonald: In the section headed definitions we find a number of luminaires listed and a suggested definition for each. Mr. Luckiesh has apparently used these same definitions in the survey which he described this morning.

It would seem that Mr. Luckiesh has left out, perhaps intentionally, one very large class of luminaires which is becoming obsolete at the present time; which is the class, that for want of a better term is called "chandelier." This is a fixture which is built up from a number of brackets either gas, electric, or combination and in which the lighting units are pointed up, down, or at an angle.

The classification given does not seem to provide any place for such fixtures and yet, at the present time, perhaps 20 per cent of the fixtures installed are of this type.

REPORT OF THE SUB-COMMITTEE ON GLARE OF THE RESEARCH COMMITTEE I. E. S.*

Your Sub-Committee was charged with such an investigation of the subject of glare as should furnish a sound foundation for definite research regarding the matter. Much work has been done in the study of glare but it has mostly been from the subjective or affective side and has not dealt with sufficiently definite physical criteria. Impressions of discomfort or fatigue are not without interest but they are too closely connected with environment and suggestion to furnish definite results. Your Committee has therefore turned to a study of glare from the standpoint of visual acuity and shade perception in an endeavor to correlate the lighting conditions with their specific effect in hindering vision. Attacking the matter from this standpoint your Committee defines glare as follows:—*Glare is the sensation produced by light so intruding the eye as to inhibit distinct vision.*

We distinguish at least three typical varieties of glare based on the nature of the particular interference with vision produced.

(1) *Veiling glare.*

Veiling glare is produced by light somewhat uniformly superimposed on the retinal image, thus reducing the contrasts and hence the visibility.

It corresponds to the fogging of a photographic plate which suppresses details otherwise visible. Practically it is found in such cases as reading under an open sky, particularly if there is a light fog, so that the eye is flooded with light other than that which is reflected from the pages of the book. A similar condition is sometimes found in trying to see even fairly conspicuous objects between two sky-lit window spaces.

(2) *Dazzle glare.*

Dazzle glare is produced by adventitious light so refracted and scattered as not to form part of the retinal image.

This corresponds somewhat to the flare spots and streaks on a plate due to an imperfect or dirty lens or lens mounting.

*A report presented at the Annual Convention of the Illuminating Engineering Society, Swampscott, Mass., Sept. 25-28, 19[illegible].

The Illuminating Engineering Society is not responsible for the statements or opinions advanced by contributors.

(3) *Scotomatic glare.*

Scotomatic glare is produced by light of intensity such as to fatigue the retinal sensativity to below the concurrent limit for visual images.

Scotomatic glare corresponds in effect with the case of heavy over exposure in photography.

Dazzle glare is the common form produced by bright lights in the field of view whether acting directly or by reflection from bright surfaces. It forms a dazzle field within which ordinary objects become quite invisible. It is due to causes at or within the refracting media of the eye.

The scotomatic glare puts a retinal area temporarily out of business by exhaustion of its active material.

To distinguish still further between these varieties of glare. In 1 the eye is functioning quite normally, but shade perception is impaired by want of contrast. In 2 the retinal images are violently light struck by the imperfections of the optical system of the eye. In 3 the cause of trouble is at the retina itself instead of at the object or in the dioptric media. Finally all these may be complicated by irradiation which is the spreading of the visual image beyond the limits of the geometrical image. Its cause broadly is scattering of light at the retina itself with consequent extension of the stimuli beyond the geometrical image. It corresponds in the photographic case somewhat to halation but more accurately to the extension of the image such as is found in celestial photography where increased exposure makes a difference in the size of star images not at all corresponding to the dimensions of the diffraction disc. Incipient scotomatic glare is often complicated by irradiation combined with imperfect fixation, so that objects having sharply contrasted detail suffer from the overlapping of after images upon other elements of the visual field. Thus in reading in a too brilliant light the negative after images of the bright elements float over and blur the details.

In attempting to obtain some quantitative ideas of these glare phenomena a test apparatus was set up as follows:— A test target 45 inches x 58 inches was prepared, having in its centre a perforation 1.5 inches in diameter. The target was covered with white cardboard of known coefficient of reflection approximately

0.74. The distance of observation was 25 feet. From the centre of the target circles were struck at radii of 1°, 2°, 3° and 4°, and on these circles were placed in various position angles black paper gummed letters. Those chosen were capital "E" and lower case "c." The "c" had a gap of approximately one foot, the same width, and an overall height quite exactly five feet. The "E" was of approximately double these dimensions. The "c" at this distance and under various illuminants check with the requirements of the Snellen chart for acuity 20/20, and correspondingly the "E's" indicated approximately 20/40. For testing the characteristics of glare a small flood light was provided for the target, but incandescent lamps of various sizes were applied as glare lamps behind the central hole in the target, and finally an automobile spot light was used for producing extreme dazzle glare such as is a serious matter in automobile practice. A Sharp-Millar photometer and a foot-candle meter especially calibrated were used to measure the intensities and brightness for the various conditions of the experiments. The preliminary observations were made by the three members of your sub-committee.

VEILING GLARE

To determine the characteristics of veiling glare a small sight box was prepared having an aperture some 2 inches in diameter through front and back of the box, which was painted dead black, while across the line of sight at an angle of 45 degrees was placed a lantern slide plate illuminated through an opening in the side of the box from a type C incandescent lamp between opal shade screens. As one looked at the target there was therefore present a clear view of the target through the glass upon which could be superimposed by shifting the opal glass along the photometer bar a variable amount of veiling glare. Having ascertained that with an illumination of 0.6 foot-candle on the target the "c" is just visible or acuity 20/20, veiling glare was introduced until acuity fell below 20/40 so that the positions of the "E's" could just be distinguished. At this degree of veiling glare the interference with vision was very marked and attempting to read the characters appeared to cause rapid fatigue. Using the Sharp-Millar instruments for a brightness photometer the ratio of brightness from the two sources was determined and

from the reflection coefficient of glass the final ratio of $\frac{B}{B_s}$ was found to be 2.6. Small amounts of veiling glare were found to produce very little loss of acuity or discomfort, but a glare brightness equal to or greater than the surface brightness would certainly prove very objectionable. This particular form of glare appears to operate wholly through degradation of contrast. The original contrast of the black paper and the standard cardboard was practically 1 : 15. The introduction of the amount of veiling glare just noted reduced this contrast to 1 : 54 = 0.0185 which checks quite accurately with the ordinary values of Fechner's fraction. And one can for objects within fairly easy acuity estimate the extinguishing value of veiling glare thus:

$$\frac{B_c}{B_s + B_g} > 0.02.$$

Here B_c is the brightness of the object, B_s as before that of the surrounding surface, and B_g that of the veiling glare. As Fechner's fraction increases the veiling glare required seriously to interfere with seeing decreases and vice versa. With relatively poor contrast with objects in the background a very small amount of glare suffices to cause trouble. One might at first associate this simple veiling glare with the difficulties in seeing brought about by glossy paper. This view is incorrect, since save under exceptional conditions all the light which reaches the eye has been reflected from the page. The difficulty in seeing print on shiny paper from which there is specular reflection comes from absolute increase of brilliancy sufficient to cause serious irradiation or, in the case of specular reflection, from loss of contrast in the print. Much printer's ink reflects specularly a considerable amount of light so that its contrast with the surrounding paper is greatly reduced. Preliminary experiments with a wedge photometer showed difference in contrast in ratio as great as 4 : 1. Precisely this sort of thing occurs in the case of an oiled road which often gives distressingly brilliant reflections.

DAZZLE GLARE

In determining this the target was illuminated to a known amount and then a lamp of known candlepower was allowed

to shine through the central hole. This hole was of dimension which fell far within Charpentier's limit, that is, the retinal image was of so small dimensions that it acted as a unit and hence the brightness of the aperture was determined merely by the candlepower of the light behind it, the entire area being effectively illuminated. Under these conditions it was found that the target as a whole emitted in the direction of observation 0.003 candlepower per square inch for each foot-candle of illumination which is equivalent to 5.8 millilamberts. Similarly each 100 candlepower in the glare lamp behind the aperture gave 56.5 candlepower per square inch of aperture or unitary brightness in the glare object of 110 millilamberts. From these data the values of B_s and B_g were obtained for the various conditions of the experiments.

In brief the results were as follows:—

A 50 candlepower type B lamp as glare lamp produced a dazzle area of nearly 1° radius so that letters on the 1° circle were much reduced in legibility but still visible. The illumination on the screen was 2.25 foot-candles.

A 200 candlepower type C lamp as glare lamp with I again equal to 2.25 foot-candles obliterated the letters on 1° circle and greatly reduced the legibility of those on the 2° circle.

With I = 0.5 foot-candle and 200 candlepower glare lamp the dazzle area extended over the 2° circle and obliterated it greatly impairing also the 3° circle.

At I = 0.3 foot-candle and 200 candlepower glare lamp the "E's" on the 4° circle were difficult, nothing inside this clearly visible. Radius of dazzle area fully 5°. The screen illumination was too low for normal acuity, acuity being reduced to about 20/40.

I = 5.9 200 candlepower glare lamp as before left everything easily visible except the "e's" in the 1° circle and even these could be made out with some difficulty. The radius of the dazzle area about 1°.

With a 500 watt glare lamp, I = 0.8 foot candle everything was obliterated except an occasional "E" in the 4° circle. Radius of dazzle spot nearly 6°.

I = 2.0 foot-candles 500 watt glare lamp reduced the circle of legibility to about 3°. Over the whole dazzle was about 5° in radius.

At I = 7.5 foot-candles 500 watt glare lamp left everything clear except the 1° circle.

In all these experiments occulting the glare lamp left everything sharply visible and there was no troublesome scotoma.

Finally an automobile spot light was used giving apparent candlepower of approximately 15,000 in an area of about 28 square inches.

With I = 6.5 foot-candles on the screen all the characters were obliterated and the radius of the dazzle area exceeded 10°.

At a screen illumination I = 1 foot-candle everything was of course obliterated and the flare extended over the whole visible field.

In all these experiments the background brightness apparently determined to a limited extent the radius of the dazzle area.

With the 500 watt lamp the brightness had to be reduced to approximately 1 per cent by means of a wedge photometer before the dazzle completely disappeared. The dazzle rays were not perceptibly polarized so that no relief was obtained by examining them with a Nicol prism.

SCOTOMATOUS GLARE

Only in case of the spot light was scotomatous glare of any material extent observed and this disappeared within two or three minutes. After the brief period of fixation necessary to examine the target some of these experiments were repeated with quite concurrent results.

CONCLUSIONS

The net results of these experiments and others like them have been to show that of the three varieties of glare dazzle glare is of far the most serious consequence. It interferes greatly with vision and is found in practical cases of bad illumination more frequently than the other varieties. In particular it is dazzle glare from reflected light that is a common and serious fault in industrial illumination deserving further investigation. Dazzle glare from a near-by object impairs the vision over a considerable angular area as related to more distant objects of vision. The

sensation is always unpleasant and the reduction of acuity and shade perception as well very great.

Veiling glare as such is comparatively rare, rather easily avoided and, depending as it does wholly on the reduction of contrast, can be reckoned with comparative readiness.

Scotomatic glare is rarely troublesome with small light sources, since it occupies a very small angular area on the retina and is much less troublesome than the usually accompanying dazzle glare. It is a familiar fact that increase in the area of the luminous source may apparently reduce the amount of dazzle which would exist were the light concentrated in a small area. One can see looking alongside a source of given total intensity the more easily as the area from which the light is given is increased, but with the larger area the scotomatic effect increases, and on looking away from the source the area affected is projected as a large and dark patch which necessarily interferes somewhat with vision to an extent which ought to be carefully determined.

In view of its preliminary investigation your Committee recommends as to the directions in which research should be pointed:—

1. That a quantitative study be made of veiling glare with respect to the extent by which reduction of contrast actually interferes with acuity so as to produce discomfort. This should include comparison of veiling glare with a mere reduction of the contrast between the object observed, as between test letters and their background.

2. With respect to dazzle glare a wide field is open for study. In the first place it is not definitely known just how and where in the refractive media the effect is produced, and in particular a quantitative examination of the extension of the dazzle area with increase in intensity of the incident light is much needed. The first matter may be materially facilitated by study of the eye under the influence of mydriatics, and the effect of monochromatic light should be included in the investigation. The relation between extent of dazzle glare, brightness of source and brightness of background should be worked out by quantitative experiments so that it may definitely appear what the effect of a

given source, either of direct or reflected light, is going to be on the general visibility of the field.

This study should be extended to the examination of sources of gradually increasing area to determine the extent to which reduction of intrinsic brilliancy and increase of area may relieve the glare conditions for a given illumination as tested by measurements of acuity and shade perception. It is well known that when the luminous area considerably exceeds Charpentier's limit the glare relations are materially changed. The extent of this change is important to be determined.

3. Finally as regards scotomatic glare your Committee recommends that the studies made with light sources of considerable area be extended to make clear their effect not only in reducing dazzle glare, but in lowering the retinal sensibility so as to interfere with vision through the production of negative after-images of the luminous area. Exposure to very large luminous sources, even of low brilliancy, materially lowers the state of adaptation of the eye and examination should be made of the extent to which this practically interferes with normal acuity and shade perception under the conditions of brilliant illumination from widely diffused sources.

Quantitative examinations in all these varieties of glare based on the variations in acuity and shade perception produced are imperatively needed to put the subject upon a definite basis freed from subjective impressions and unconscious suggestion.

Respectfully submitted,

SUB-COMMITTEE ON GLARE,

LOUIS BELL, *Chairman*

L. T. TROLAND

F. H. VERHOEFF

GENERAL SECRETARY'S REPORT FOR THE FISCAL YEAR 1921-1922

BY CLARENCE L. LAW

INTRODUCTION

During the period just passed, constituting the sixteenth fiscal year of the Society, a decided progress has been shown as a result of the Society's activities. The foundation for future work has been made during the past administration which should develop most interesting results. The dissemination of the Society's principles and practices should necessarily be promoted through the medium of sections and chapters and it is therefore fitting that some effort be made to increase the existing membership of these sections and chapters. A committee for this purpose was appointed by the President and through this medium it is hoped that there will be an increase in the number. Meetings have been held regularly in the various cities where we have representation. The character of the papers presented under discussion were of the usual high standard and shows a continued interest in the subject of lighting.

COUNCIL

The Council of the Society during the past year had meetings regularly each month with the exception of July and August when the Executive Committee transacted the necessary business. The usual keen interest has been manifested by the individual members during the transaction of the Society's affairs. The General Office has been conducted without any change in the personnel of the staff. The individual members of the Council have endeavored to assist the various committee chairmen and the members in carrying out the many details of their committee work.

MEMBERSHIP

The membership of the Society is divided into four classes: member, associate member, student member and sustaining member. It may be of interest to note some statistics regarding each class in order to convey an idea of the membership status.

Sustaining Members: From this source is derived the largest revenue, which is approximately 30 per cent of the total revenue of the Society. As of September 30, 1922, the sustaining members were 80 in number and had contributed an annual income of $6,579.50. The corresponding figures for the last year show 87 sustaining members who contributed an income of $8,112.50. The decrease in revenue for the past fiscal year from this source was $1,533 or a decrease of 18.8 per cent. Although the Society may have nothing tangible to show as a result of sustaining membership, there can be most assuredly pointed out advantages accruing to companies as a result of affiliation. To this class of membership the Society will assist as far as possible in the direction of furnishing information of any character pertaining to illuminating engineering.

Members: From this source is derived 26 per cent of our revenue. The number of members this year is 384 as compared with 384 at the end of last year. The revenue derived this year was $5,732.49 against $5,707.50 last year, an increase of 0.4 per cent.

Associate Members: From this source is derived 24 per cent of our revenue. The number of associate members this year is 810 as compared with 799 last year, a net gain of 11. The revenue derived this year was $5,699.73 against $5,820.99 last year, a decrease of 2.1 per cent.

Student Members: There has as yet been no activity in obtaining new members of this class. There is a very promising field for effort in this direction through the medium of our chapters, and it is hoped that during the coming year this class of membership will be fostered.

In Table I is found a detail summary of the total membership of the Society for the present fiscal year. Fig. 1 shows the total membership at the end of each year from 1906 to date.

LOCAL REPRESENTATIVES

The Local Representatives of the Society now number thirty-five, and are situated in twenty-two states of the Union, in Australia, Canada, and South Africa; in September, 1915, the Society had nine Local Representatives.

TABLE I.

Class of membership	Honorary members	Members	Associates	Total	Sustaining members
Membership Oct. 1, 1921	2	384	799	1183	87
Additions					
Transferred		3	4		
New members qualified		34	137		4
Re-elected		3	1		
Re-instated		5	8		
Sub-total		45	150		
Deductions					
Deceased		3	5		
Resigned		20	47		11
Dropped		18	84		
Transferred		4	3		
Sub-total		45	139		
Increase		0	11	11	
Membership Oct. 1, 1922	2	384	810	1194	80
Net Increase During Year in Membership		0	11	14	

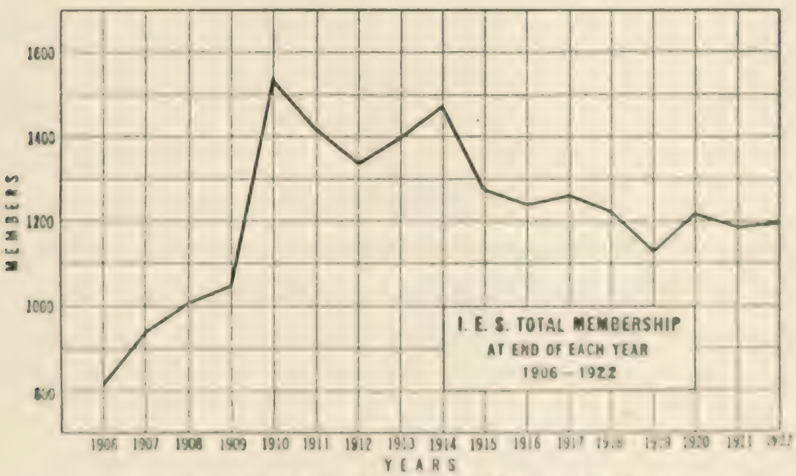


Fig. 1.—Variation in Membership since 1906

The functioning of the Local Representative is important and offers great possibilities in furthering the activities of the Society. Every state in the Union should have at least one Local Representative to promulgate the aims and objects of our Society.

SECTIONS AND CHAPTERS

An increasing interest on the part of many who are not members of the Society is indicated in the annual reports received from the various sections and chapters. The policy of holding joint meetings with other organizations and technical societies

by the sections and chapters has proved fruitful in bringing about this added interest. The papers discussed at these meetings were of value and a large number of them have been published in the TRANSACTIONS.

Many valuable suggestions were included in these annual reports for improvement in the management of the sections. These items covered details of attendance, exhibition, membership, papers, and publicity.

The following table gives the average attendance, and the number of papers presented at the Section and Chapter meetings.

TABLE II.

Section	Number of meetings	Papers presented	Average attendance
Chicago	6	6	62
New England	5	7	48
New York	8	14	138
Philadelphia	8	10	134
Chapter			
Cleveland	3	3	40
Toronto	8	8	38

COMMITTEES

Committee on Editing and Publication: The Committee on Editing and Publication has functioned continually since its appointment, and upon taking office found itself handicapped in the issuing of the TRANSACTIONS due to the printers' strike and the discussion regarding the change in form of the TRANSACTIONS. However, this committee gradually decreased the delay, and has supervised the publication of the ten issues covering the past administrative period.

In January the change in the style of the TRANSACTIONS was made which, in the opinion of the committee, has made them more attractive and more in accord with the progressive journals of other societies.

The number of the TRANSACTIONS has been increased to ten during the year, which includes a monthly journal. A new feature is the monthly editorial written and signed by men prominent in the Society commenting on questions of timely interest. A section entitled "Reflections" has also been included which seems to

be of interest to the membership. Abstracts of papers of general interest in addition to papers presented to the Society are also embodied in the new form.

An unusual sale of reprints has been made during the past year. In order to present an idea of this increase a comparison has been made with last year, which shows that this year a sale of 14,733 reprints was made with a total profit to the Society of $349.42 against a sale of 875 reprints the previous year, with a net profit to the Society of $13.37.

The Editing and Publication Committee in its report makes some excellent recommendations to the new committee to make the TRANSACTIONS more attractive.

Committee on Membership: The Membership Committee has worked energetically to create enthusiasm in order to secure new members, and has received the co-operation of a large percentage of the membership including some of our Associate Members. Despite business conditions and the fact that other technical societies have shown a falling off, our membership has increased over last year.

Committee on Nomenclature and Standards: This committee is presenting a report in detail of its work during the past year.

The term "Luminaire" which was recommended by the committee last year has been formally approved by a resolution of the Standards Committee of the American Institute of Electrical Engineers.

The committee reports further progress in view of the fact that the Society's reports on Nomenclature and Standards have been formally approved as American Standard by the American Engineering Standards Committee on July 11, 1922.

Committee on Lighting Legislation: During the year 1921, the I. E. S. Code of Lighting Factories, Mills and Other Work Places was revised by the Committee on Lighting Legislation in co-operation with a Sectional Committee acting under the auspices of the American Engineering Standards Committee. On December 31, 1921, the Code was unanimously approved by the A. E. S. C. as the American Standard.

The policy of the committee has been to bring the Code to the attention of Departments of Labor and Industrial Boards and

to co-operate with them in introducing the Code. Among the organizations with which the Committee has actively co-operated during the past year is the International Association of Industrial Accident Boards and Commissions. The Code is in force in six states as follows: California, New Jersey, New York, Oregon, Pennsylvania and Wisconsin. It is being tried out in Ohio and Massachusetts. Several other states now have the adoption of the Code under consideration.

The Factory Lighting Code of New York was revised during the year in respect to the glare rule and also the rule relating to minimum intensity of light required for detailed industrial operations and processes. The revision was effective May 1, 1922.

During the year a law was passed in New York State giving the Industrial Commission jurisdiction over the matter of Safety in Places of Public Assembly. A code is now being prepared which will include the subject of lighting. The Commission has requested the Committee on Lighting Legislation to advise as to safe lighting requirements.

The Council has authorized the committee to revise the School Lighting Code, issued by the Society in 1918. Data for this revision are being gathered.

The International Commission on Illumination has planned a conference to be held in 1924 at which an effort will be made to bring about uniformity, so far as is practicable, in the Factory Lighting Codes and School Lighting Codes of various countries and states. The Committee on Lighting Legislation is co-operating in this movement.

CONCLUSION

In concluding this brief report may I take the opportunity to express my appreciation for the assistance which has been rendered me, not only during the past year, but during the entire term of my five years in the office of General Secretary. It has not only been an honor but a pleasure to serve in that capacity and to aid in the promotion of the Society's affairs and well being. In turning over the office, I do so with the hope that my successor as General Secretary will find his associations with the work and the members a real benefit and pleasure as I have.

APPENDIX

New York, October 16, 1922.

Illuminating Engineering Society,
29 West 39th Street,
New York City.

Dear Sirs:

Pursuant to my engagement, I have audited your accounts for the fiscal year ending September 30, 1922, and present appended hereto the following Statements:

Exhibit 1—Balance Sheet, September 30, 1922.

Exhibit 2—Statement of Income and Expenses—For Fiscal Year Ending September 30, 1922.

The Cash in bank and in office was proved correct. The Liberty Bonds, in the custody of the Treasurer, were not examined. The inventories were estimated by the office staff at the figures shown. Furniture and fixtures was increased by $448, representing the cost of partitions, etc., in your present office. Depreciation has not been deducted from this asset as the actual depreciation of value is small.

The Statement of Income and Expenses (Exhibit 2) is compiled on an accrual basis. Its first section shows the income and expenses pertaining to the year ending Sept. 30, 1922, and shows a Net Income of $340.02.

Adjustments pertaining to the prior year are shown in the last section of Exhibit 2 and their nature is stated therein. The Net Total thereof is $1,654.55, which deducted from the Net Income—Current Year, $340.02, makes a Net Deficit of $1,314.53.

The Surplus at Oct. 1, 1921 was	$3,847.30
and deducting the Net Deficit of	1,314.53
leaves the Surplus at Sept. 30, 1922, at	2,532.77

Respectfully submitted,
(Signed) KENNETH FAIRBANKS,
Certified Public Accountant

EXHIBIT I

BALANCE SHEET—SEPTEMBER 30, 1922

ASSETS

Cash in Bank and Office		$ 844.23
Liberty Bonds		3,000.00
Accounts Receivable:		
Members' Dues	$ 0	
Associate Members' Dues	8.50	
Sustaining Members' Dues	400.00	
Initiation Fees	0	
TRANSACTIONS	22.59	
Advertising	3.50	
Miscellaneous	84.48	519.07
Inventories:		
Badges and Reprints	128.00	
TRANSACTIONS—Illustration Cuts	270.00	398.00
Furniture and Fixtures		1,033.30
		$5,794.60

LIABILITIES

Accounts Payable—Vouchered		$2,809.99
Accounts Payable—Estimated		350.00
Dues and Fees Paid in Advance	$ 95.09	
TRANSACTIONS Paid in Advance	6.75	101.84
Loan for Educational Purposes		0
Surplus		2,532.77
		$5,794.60

Surplus—Oct. 1, 1921	$3,847.30
Less—Net Deficit, Year Ending Sept. 30, 1922	1,314.53
Surplus—Sept. 30, 1922	2,532.77

EXHIBIT 2

INCOME AND EXPENSES FOR FISCAL YEAR ENDING SEPTEMBER 30, 1922

Income

Members' Dues	$5,732.49		
Associate Members' Dues	5,699.73		
Sustaining Members' Dues	6,579.50	$18,011.72	
Initiation Fees		360.00	
Back Dues		0	
TRANSACTIONS Sales		1,387.83	
Advertising Sales		1,483.50	
Miscellaneous Sales		407.02	
Royalties on Sales		19.80	
Interest—Bank	107.18		
Interest—Liberty Bonds	108.75	215.93	
Total Income			$21,885.80

Expenses

TRANSACTIONS		$ 7,047.78	
General Office Expenses:			
Salaries	$6,566.00		
Rent	1,560.00		
Printing, Stationery, Supplies	558.16		
Postage	375.91		
Telephone, Telegrams, Express	222.53		
Miscellaneous	782.97	10,065.57	
Committee Expenses	371.64		
Committee on Education, Expenses	117.50		
International Commission on Illumination	300.00	789.14	
Educational Course Preparatory Expense	0		
New York Section	529.86		
Philadelphia Section	506.23		
Chicago Section	367.06		
New England Section	348.23		
San Francisco Chapter	0		
Cleveland Chapter	8.73		
Toronto Chapter	0	1,760.11	
Convention Expenses		1,883.18	21,545.78
Net Income—Current Year			$ 340.02
Adjustments of Prior Year Expenses			
TRANSACTIONS Expense	$1,502.85		
Convention of 1921 Expenses	290.16		
Accounts uncollectible	12.70		
Total	$1,805.71		
Less—Educational Course Expenses Refunded	151.16		1,654.55
Net Deficit (Deducted from Surplus)			$1,314.53

ABSTRACTS

In this section of the TRANSACTIONS there will be used (1) ABSTRACTS of papers of general interest pertaining to the field of illumination appearing in technical journals, (2) ABSTRACTS of papers presented before the Illuminating Engineering Society, and (3) NOTES on research problems now in progress.

LIGHTING IN RELATION TO SAFETY

This is the subject of a pamphlet issued by the Edison Lamp Works of the General Electric Company and is one of a series of bulletins on the general subject of lighting. Because of the greatly increasing interest in the safety movement from both the welfare and the financial points of view a study of the relation of adequate illumination to safety is of interest. A discussion of the magnitude of the safety question is followed by examples of improper lighting—glaring lights, insufficient lighting, improperly placed lights, etc.—and of correct and adequate lighting to show how safety is retarded or promoted thereby. The pamphlet states:

"In a well lighted shop, obstructions being more readily visible, are much more likely to be removed, or even if not removed, are likely to be seen by the workmen, and thus accidents are avoided.

Similarly, over a wide range of conditions, good illumination is the best possible warning of danger, facilitating the removal of the cause and further helping the employee to see any dangerous conditions and thus avoid danger. An employee is certainly entitled to this protection. Few employers would think of letting a blind man go in among powerful machines in a workshop, yet it often happens that they render an employee partially blind by glaring or inadequate illumination.

It is impossible so to guard a sharp-cutting tool that it is not possible for an operator to reach its danger point. If it is not clearly visible, injury is liable to occur, even though the best obtainable device is used.

A peculiarity of good lighting is that it differs from many other safeguards in that it assists rather than impedes the workman, thus contributing toward raising the quality and quantity of the product. In other words, it pays from every point of view."

The writer also points out the value of proper lighting for automobiles, public and private buildings and streets, asserting:

"In all walks of life, and in all occupations or recreation, artificial illumination is a necessity, not alone from the standpoint of making movements possible through the ability to see, but also from the humanitarian standpoint of assisting in making all of these safe."

RESTORATION OF BURNED-OUT INCANDESCENT LAMPS

BY H. LUX

The article gives a review of the many possible methods of renewing the broken or burned-out filaments of incandescent lamps. Four main methods for such renewals are known: (1) The glass bulb may be made with a joint in the first place; (2) the bulb may be opened at the exhaustion tip; (3) same as in (2), but additional openings are made near the base of the lamp; (4) the bulb is cut open along the base and afterward resealed. The fourth method is being used to some extent in England and Germany, where the present high cost of new lamps makes the renewing of old lamps a commercial success.—*Zeitschrift für Beleuchtungswesen*, Aug. 14 and 31, 1922.

THE USE OF LIGHT IN HOSPITALS

The Illuminating Engineering Society (London) arranged a joint discussion with the Royal Society of Medicine to discuss the chief problems in the use of light for hospitals, particular attention being devoted to lighting of wards and operating tables. The introductory paper by Mr. Darch was supplemented by a series of questions with the object of inviting additional information. The introductory paper tells the requirements for lighting operating tables. These requirements are very exacting. The discussion brought out valuable information on lighting of hospitals in general, wards, operating tables, special inspection lamps, microscope illumination, illumination of colored objects, the lighting of pathological museums and the lighting of dispensaries.—*Illuminating Engineer* (London), Vol. XV, No. 6.

LIGHT AND ILLUMINATION*

SUGGESTED RESEARCH SUBJECTS SUITABLE FOR GRADUATE AND UNDERGRADUATE THESES

Compiled by the Committee on Education, Illuminating Engineering Society

August, 1922

This list of research subjects covers a wide range of adaptability to different conditions and to investigation of varying degrees of experience. Great care should be exercised by instructors in charge of the thesis so that the student will undertake a subject well suited to his individual needs. The subjects have been suggested by a number of the most successful investigators in the illumination field. The chairman of the committee on education will be glad to put any investigator in touch with the proposer of a listed topic, or to afford any other assistance within his power. Inquiries should be sent to F. C. Caldwell, Ohio State University, Columbus, Ohio.

BRIGHTNESS

A survey of typically lighted interiors to determine brightness of source and other surfaces.

COLOR

The collection of data regarding color vision.

Light for matching colors for use under artificial illuminants.

Light for matching colors for daylight use.

Can color of sky, clouds, etc. be expressed as a color temperature above 5,000° or is there distortion?

DAYLIGHT PROBLEMS

A detailed survey of factory day-lighting in any industrial center.

Window design (factory, office or school) from the standpoint of good lighting.

The changing colors of daylight, diurnal, seasonal, etc.

* Abstracted from the annual report of the Committee on Education for 1921-1922.

Sky brightness and color as meteorological indications of imminent weather conditions.

Show window lighting with a view of eliminating daylight reflections.

ELECTRIC ADVERTISING ECONOMICS

Cost of electrical advertising displays and their value in terms of circulation as compared with newspaper, magazine, street car and other forms of advertising.

Relation of number and permanency of impressions to circulation, for electrical advertising as compared with other forms.

Study of economically desirable period of change in copy or form of electrical advertising displays of various characters.

ILLUMINATION

A survey of illumination on eye-charts in use by opticians and oculists.

A detailed survey of factory artificial lighting in any industrial center.

A detailed survey of store window lighting in any locality.

The drawing power of light in a store; provide increased illumination for counter or section, and note the relative number and value of sales.

A survey of the lighting in college study rooms.

What are the safe minimum intensities required in various industrial operations and processes?

Proper ratio of minimum daylight intensity to artificial light intensity.

Factory lighting in its relation to production.

The economic aspect of street lighting—saving through decrease in crime—lesser police force—decreased accidents. Promotion of business through greater use of streets at night, greater cheerfulness, etc., (several theses).

Speed of drafting as affected by illumination with many observers.

Speed of reading as affected by illumination with many observers.

The feasibility of planning or analyzing industrial lighting upon the basic of the brightness of working surfaces rather than upon the basis of foot-candle values upon those surfaces.

Surveys of maintenance found in different classes of lighting, (several theses).

ILLUMINANTS

Voltage—actinic studies of artificial illuminants.

Voltage—candlepower studies of modern illuminants.

Photographic characteristics of the mercury-vapor light.

A study of the true evaluation of lamp quality.

GLARE

Study of glare due to daylight, as affected by varying conditions, as of brightness, volume, contrast, etc. Obtain judgments of many observers, (several theses).

Permissible glare under various conditions as of brightness, volume, contrast, time of exposure, etc., (several theses).

Permissible glare from flood-lights under various conditions, (many observers, several theses).

Glare studied from the points of view of the following five factors or combinations of two or more, (a) Intrinsic brightness, (b) Candle-power in the direction of the eye, (c) Angular position of the light source, (d) Brightness contrast with the background, (e) Length of time the eyes are exposed, (many observers, several theses).

A study of the methods of determining and classifying degrees of glare.

Design of illuminated signal system for handling street traffic of a given city.

Specifications and measurement of glare, development of a practicable, portable measuring instrument.

Speed of reading as affected by veiling glare, (many observers).

LIGHTING ACCESSORIES

Depreciation of lighting units due to dust collection in different classes of use, as schools, factories, etc., (several theses).

Depreciation of lighting systems due to darkening ceiling and walls in different classes of use, (several theses).

Relations between ventilation and temperatures (including dust deposits) of enclosing lighting units.

Where a large number of similar globes or reflectors are available, a study to determine variations from the mean transmission.

A study of the brightness relation on typical luminaires comparing average maximum brightest square inch, brightest half square inch, brightest one-quarter square inch.

MISCELLANEOUS

A survey of local homes, to give number of occupants, number of rooms, number of outlets, number and wattage of lamps, classification of fixture equipment.

A study of electrical resistance of glass under various temperatures. (This has to do chiefly with incandescent lamp bulb manufacture).

Radium salts, applications to electric lighting devices, and furniture.

Use of incandescent lamps in japanning ovens as a substitute for gas or oil.

PHOTOMETRY

A comparative study of the portable illumination measuring devices, such as Macbeth Illuminometer, The Sharp-Millar Photometer, the Holophone Light Meter and the Weber Photometer.

In direct measurement of sources of different colors the determination of the relative candlepower of lamps at different voltages over a considerable range, or of lamps of different types. Such measurements to be made by considerable numbers of observers.

Comparison of results obtained by equality of brightness and flicker methods and determination of the effect of conditions such as field size and field brightness.

Relative precision of measurements by equality of brightness and flicker methods and under different conditions such as different ranges in color differences and different field conditions.

The collection of data from numbers of observers on the results obtained with typical color differences, with equality of brightness and flicker photometer methods.

The choice of a satisfactory standard method for the comparison of lights of different colors.

On the effect of variation of brightness of field size on the observed relative brightness of lights of different colors.

On the effect of brightness of the surrounding field on the sensitivity of the photometric instrument and of the color of the surrounding field on the results obtained.

The effect of position of source in the sphere photometer.

Effect of variation of size and position of screens in measuring sources, which have different distributions of light, in the sphere photometer.

Effect of lack of perfect diffusion in window and in sphere photometer surface.

Effect of lack of perfect whiteness of window and sphere photometer surface in comparing lights of different colors.

The errors entering into spectrophotometry, particularly due to feeble fields of view, stray light, etc.

Comparison of reflection factor measurements using light incident, (1) diffusely, and (2) normally on the surface. The first is the standard sphere reflectometer method; the second, the older distribution method.

PROJECTION, MOVING PICTURES

Investigation on the intermittent used on motion picture machines; also other characteristics of the optical system.

A study of the functioning of shutters on motion picture projectors particularly with reference to the limiting blade requirements for single and double disc shutters and including both solid and translucent blades, (with a student of psychology).

A study of the relation of picture size (on screen) to satisfactory projection. This would involve considerations of brightness, distance of observer from screen, angle with screen, etc.

Eye fatigue in moving picture audiences and its reduction.

Mat and specularly reflective screens and their use in rooms of different dimensions.

PSYCHOLOGICAL AND PHYSIOLOGICAL

Maintenance of vision and eye fatigue under various conditions, (many observers. See papers by Ferree and Rand).

The reduction in ability to distinguish objects or brightness differences as depending on the total candlepower of a light source in the field of view, (many observers).

The reduction in ability to distinguish objects or brightness differences as depending on brightness of a light-source in the field of view, (many observers).

The reduction in one's ability to distinguish objects or brightness differences as depending on angle of a light source in the field of view, (many observers).

The study of the time factors involved in visual sensations such as occur in after images.

Visual acuity under varying conditions of contrast; use a sufficient number of men to insure normal results; use the broken ring test with the test objects cut out of Velox paper exposed in varying degrees and tested in the photometer for its reflection coefficient, (several theses).

Effect of an illuminated foreground on acuity, visibility or the ease with which objects are revealed at a distance by other sources of illumination, or illumination proceeding from the same source.

Speed of vision as affected by illumination; conditions varied as by size of objects, contrast with background, colored objects and backgrounds, etc., eye adaptation by time of exposure, abnormal eyes, etc., (many observers, several theses).

Acuity of vision as affected by illumination; conditions varied. (many observers, several theses).

Pupillary areas as a function of wave length and energy of stimulation.

Is there sufficient heat radiation from welding arcs and flames, steel furnaces, etc., to cause injury to the eye, (joint thesis with student in zoology or medicine).

Effect of ultra-violet light between visible and about 0.3 mikron upon the eye. Use Corning glass G586AW for isolating 0.365 mikron radiation from mercury arc, (joint thesis with student in zoology or medicine).

Relation of psychology of seeing and quality and intensity of illumination.

REFLECTION, TRANSMISSION AND ABSORPTION

Absorption and permanence of color screens, colored glass or colored liquids.

Investigation of the absorption of dips, color caps and colored glass globes used for sign and decorative lighting.

Changes in the light reflection values of different color substances under different colors and qualities of illumination.

The measurements of reflection coefficients using mercury vapor lighting as the source.

Refraction and transmission of light through irregular sheet glass surfaces.

Light reflecting values of book and print papers and inks.

Light reflecting values of various metal and wood surfaces.

A study of the action of smoke, fumes, and acids on the silvered, polished and enameled reflector surfaces.

The investigation of the color and kind of paint which will give the best results with different types of lamps for sign lighting.

The penetration of colored lights through fog and dust.

SPECIAL EFFECTS OF LIGHT

Effects of light upon fermentation and bacterial growth.

Effects of artificial light upon plant growth.

Effects of artificial light upon production of eggs from hens.

Bleaching actions of electric illuminants.

STREET LIGHTING AND TRAFFIC SIGNALS

Method of specifying street illumination horizontal or vertical illumination.

Place of silhouette vision in street lighting.

Best height and candlepower for street lighting of different types.

SYSTEMS

Series street lighting lamps with a particular view of ascertaining performance of two-coil and compensator types of transformers in conjunction with high amperage series lamps and an investigation of choking actions and current maintenance of transformers on secondary street lighting circuits. This investigation might further include measurements of voltage drops in sockets and secondary circuits of series lighting systems.

The design of a remote control switch operated from the central station on the regular multiple lighting circuits for controlling street series systems in remote districts.

Errors in the measurement of voltage or current in alternating circuits due to the wave form by using the usual types of port-

able instruments as compared with the results obtained by using instruments which are considered unaffected by wave form such as those of the dynamometer type.

VEHICLE LIGHTING

The best distribution of light in the beam of headlamps of automobiles to meet the conditions on the road, (many observers).

The legibility of automobile license tags with regard to intensity of light, color of plates and speed of vehicle, (many observers).

Reflectors for use with a concentrated incandescent light source, tending particularly toward the design of optical headlights.

Effect of color of headlight on candlepower needed to produce objectionable glare, (many observers).

Analysis of desirable electrical system and illumination equipment for farm tractors, (with a student of agricultural engineering).

Functioning of battery-generator starting and lighting systems for motor vehicles and the possibility of line or system regulation through the use of vacuum tubes so as to provide substantially uniform voltage for lighting.

Actual service illumination from automobile headlighting equipments of approved types; the factors responsible for the discrepancies between service and laboratory results and analysis of corrective measures.

SOCIETY AFFAIRS

SECTION ACTIVITIES

NEW YORK

Meeting—November 9, 1922.

At the meeting of the New York Section held in the auditorium of the Consolidated Gas Company Building on the evening of November 9th, the topic of residence lighting was presented. Mr. W. H. Rademacher of the Edison Lamp Works gave a lecture and demonstration of apparatus on the subject, "Common Sense Electric Lighting in the Home." By the use of a revolving stage, the contrast of poor and good lighting in the home was shown. Both kinds of illumination were produced in the living room, dining room, bedroom and kitchen.

Mr. R. H. Maurer of the Consolidated Gas Company demonstrated a number of gas luminaires which could be used in the home. The display of the gas luminaires consisted of floor lamps, table lamps and wall brackets.

A very interesting discussion was held and about one hundred and ten members and guests were present.

PHILADELPHIA.

Meeting—November 14, 1922.

The Philadelphia Section met at the Engineers' Club on November 14th, to discuss the topic of school lighting. Mr. Davis H. Tuck of the Holophane Company of New York City gave a talk, illustrated with lantern slides, on the general subject, which was followed by a good discussion. About forty members and guests were present.

CHICAGO

Meeting—November 22, 1922.

A joint luncheon meeting was held on November 22, with the Office Building Managers Association at the Great Northern Hotel. Mr. E. D. Tilson of the Commonwealth Edison Company presented a paper, "The Illumination of Office Buildings." There was no general discussion.

At the meeting of the Board of Managers held on the same date, Mr. William Goodrich of the Western Electric Company, 500 South Clinton Street, Chicago, was elected to the board in place of Mr. W. T. Blackwell, resigned.

NEWS ITEMS

The Membership Drive

The Membership Drive under the able leadership of Mr. G. Bertram Regar, of Philadelphia, is making splendid progress. The entire membership of the Society have received a letter from the chairman outlining the progress of the work. It is the duty of every member to help in this campaign. The return postal card should be mailed promptly, and every effort will be made in following up prospective applicants by members of the committee. Concerted action by all will result in a larger membership, and the activities of the Society will be expanded.

Illumination Activities in Russia

There has been recently organized in Petrograd a special commission on Illuminating Engineering by the Central

Electrotechnical Council of the Republic of Russia. The following officers have been appointed: Prof. M. de Chatelain, Chairman; Prof. M. Bogoslovsky, Vice-Chairman; P. Tikhodeeff, Secretary.

The problems of the commission includes all questions concerning lighting and lamps of all kinds, and the consideration of photometric standards. As electricity and oil are the only sources used in illumination in Russia the question of gas lighting has not yet been examined.

Prof. M. de Chatelain is a member of the I. E. S. and would appreciate the cooperation of American illuminating engineers.

PERSONALS

Mr. E. H. Whitney, formerly of the Westinghouse Lamp Co. as District Illuminating Engineer in Boston, Mass., has become connected with the Westinghouse Elect. and Mfg. Co., as assistant to the Manager of Interior Lighting Section at South Bend, Ind.

Mr. Morgan Brooks, who is on a leave of absence from the University of Illinois, recently gave a lecture on "Illumination" before the Czecho-Slovakia Society of Engineers and Architects at Prague.

ILLUMINATION INDEX

PREPARED BY THE COMMITTEE ON PROGRESS.

An INDEX OF REFERENCES to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

		DATE	PAGE
Annalen der Physik			
Über die Lichtwirkung auf Zinksulfid—	P. Lenard	Oct. 4	553
Central Station			
Black Streets are Back Streets—	L. A. S. Wood	Oct.	102
A Survey of Residence Lighting—	M. Luckiesh	Oct.	106
I. E. S. Notes (Swampscott Convention)—		Oct.	126
Chemical Abstracts			
Electrical Conductivity in Electronically Poor Solid Conductors. Experiments with Mercury Iodide. (Effect of Light on Electrical Resistance) (from *Annalen Physik,* 66, 463-96, 1921)*—	F. Kämpf	Oct. 20	
Wire-shaped Crystals of Tungsten—	R. Cross and N. Blassmann	Oct. 10	3239
Electrical World			
Investigations of the Conditions in Residence Lighting—Editorial—		Oct. 14	808
Ornamental Lighting System Installed for $100,000—	P. B. Reed	Oct. 14	829
What a Store-Lighting Survey Shows—	Oliver R. Hogue and James J. Kirk	Oct. 14	832
Reckoning the Cost of Daylight—Editorial—		Oct. 21	861
Development of Incandescent Lamp for Street Lighting—		Oct. 21	877
Elektrotechnischer Anzeiger			
Glühlampenschutz gegen Diebstahl—		Sept. 16	1167
Elektrotechnische Zeitschrift			
Betrag zur Theorie der Raumbeleuchtung—	R. Ulbricht	Oct. 12	1262

*Not previously reviewed

Radioactivity of Incandescent Gas Mantles (from *Chem. Zentralbl.*, Feb. 22, 1922, I., p. 440)—	P. Hanck	Oct.	414
N. E. L. A. Bulletin			
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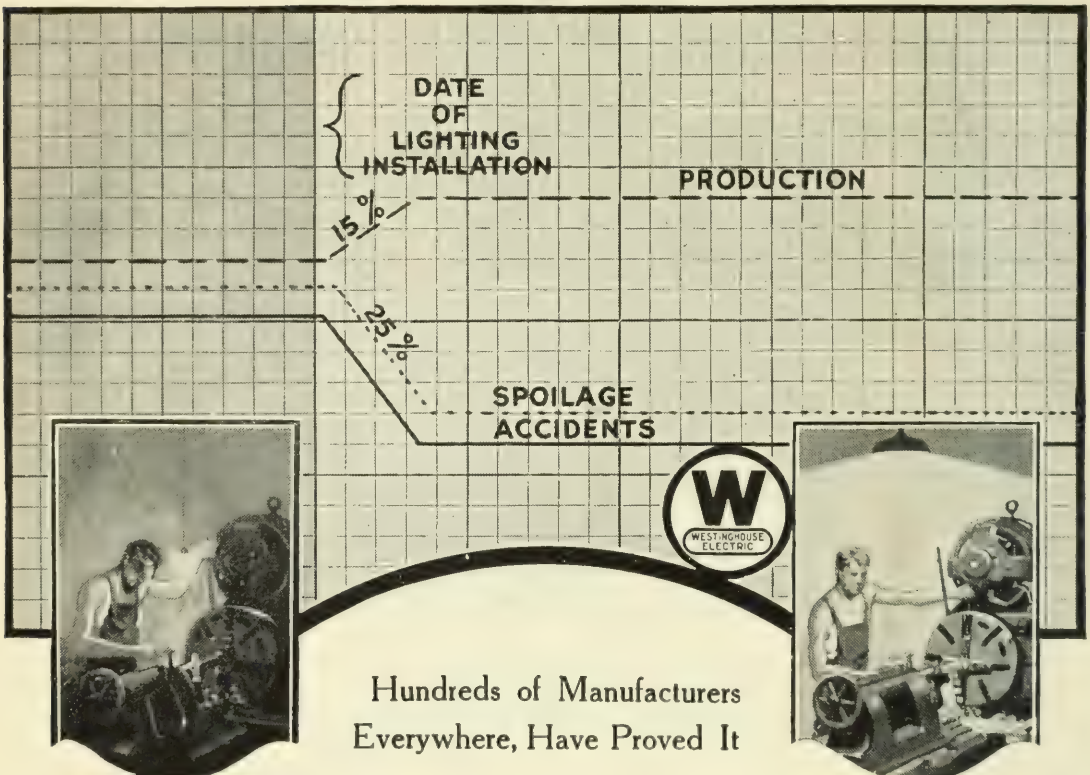

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